BELL & HOWELL SCHOOLS

MANUAL 9501

DESIGN CONSOLE—CONSTRUCTION

A guide for use in construction of materials in
ELECTRO LAB® Design Console Scientific Kit.

CONSTRUCTION MANUAL FOR THE ELECTRO-LAB® DESIGN CONSOLE

9501

Revised 1974

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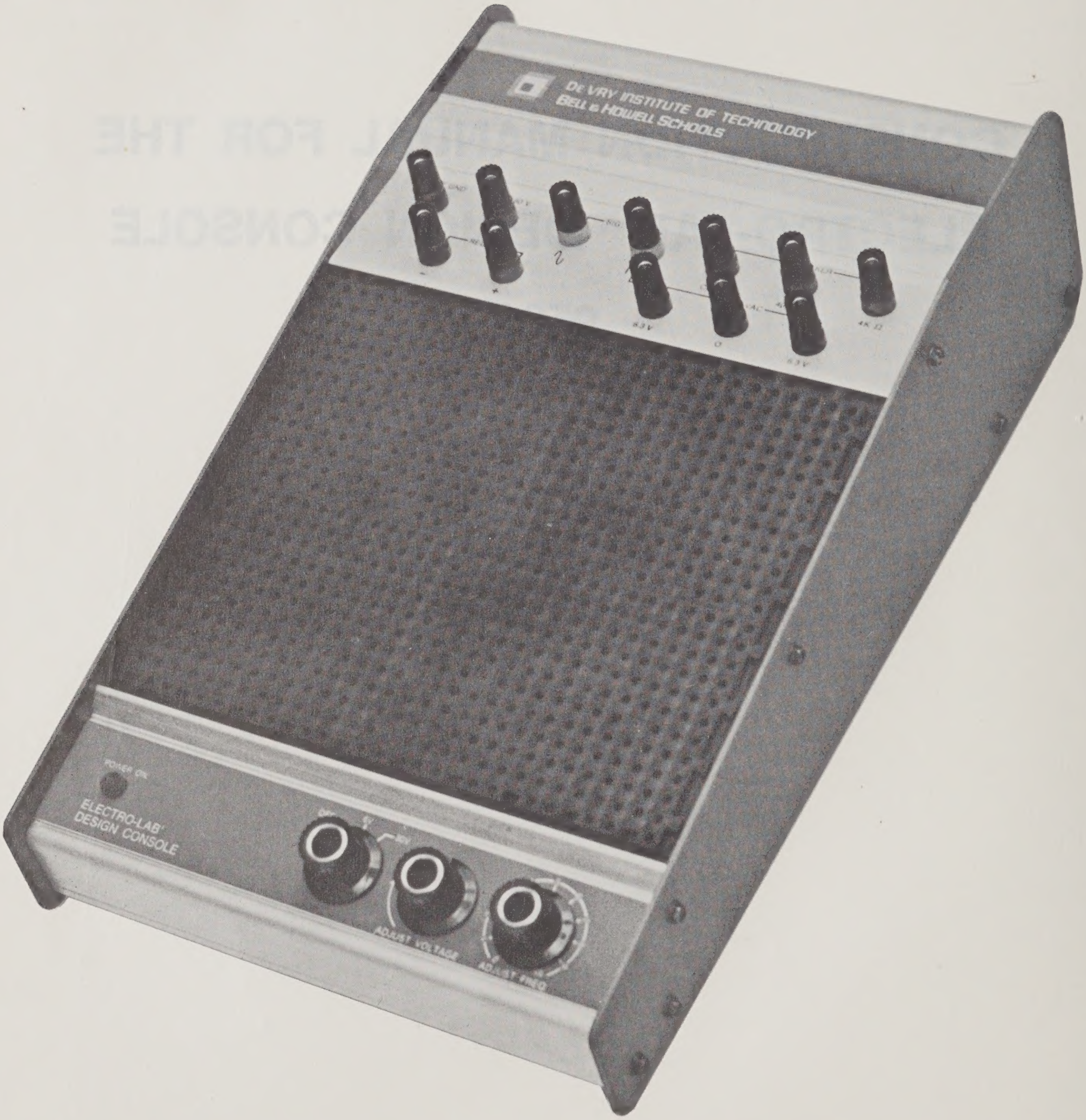

This laboratory unit contains an adjustable regulated power supply, auxiliary dc and ac power, a sinewave and square-wave signal generator, and speaker with matching transformer. Its use permits the study and design of electronic circuits with a minimum of construction time.

THE ELECTRO-LAB® DESIGN CONSOLE

DeVry Photo

CONSTRUCTION MANUAL FOR THE ELECTRO-LAB® DESIGN CONSOLE

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CONSTRUCTION MANUAL FOR THE ELECTRO-LAB® DESIGN CONSOLE

INTRODUCTION

This manual contains general information and assembly directions for the construction of the Electro Lab® Design Console. After the completing of each project, you will use the Design Console for a group of experiments which will illustrate the characteristics and uses of components and circuits. Instructions for these experiments are in your Laboratory Experiment Manuals.

The completed design console is a self-contained laboratory that may be used for developing circuits and systems of your own. Ease of constructing circuits, coupled with the design console features of built-in power supply and generator, will make this an important piece of equipment in your laboratory.

GENERAL INFORMATION

Discussion

Construction of the complete Electro Lab® Design Console is carried out in 3 separate projects. For each project you will receive a shipment of construction parts and the experimental parts to be used for study and experiments following that construction project. When you are ready to begin the next stage of design console construction, you will turn to the next project in this manual.

UNPACKING

When a carton arrives, open it carefully so that none of the parts or printed material it contains is damaged. The carton may be used for storage of parts when they are not being used. Do not discard any inner envelope, bag, package, packing material, or printed matter until you have completed that particular construction project.

IDENTIFYING AND SORTING THE PARTS

Two sets of parts are included in each shipment. They are:

1. electrical and mechanical parts for design console construction, and
2. electrical and mechanical parts for the experimental work that follows design console construction. The parts for the experiments will be in a separate package that is clearly marked.

At the beginning of each step or section in the construction procedure, you will find a line enclosed in parentheses. It looks like this: (_____). As soon as you have completely finished that step or portion of a step, put an "X" on that line. This will allow you to quickly determine the last step, or section of a step, that you completed.

(_____) Step 1

Find the experimental parts package and put it aside. These experimental parts will be identified later, and checked against a parts list in your Laboratory Experiments Manual.

(_____) Step 2

Identify the construction parts and sort them into 5 separate groups:

1. resistors,
2. capacitors,
3. semiconductor devices,
4. hardware, and
5. wire and solder.

To identify these parts, refer to Figures 1, 2 and 3. These figures are found at the end of this section.

(_____) Step 3

WHEN you begin a construction project, check every part against the materials list in the order given in Step 2. It may be a good idea to keep the parts separated by placing each group in a separate box or other container. This will make it easier to pick out the parts as you need them.

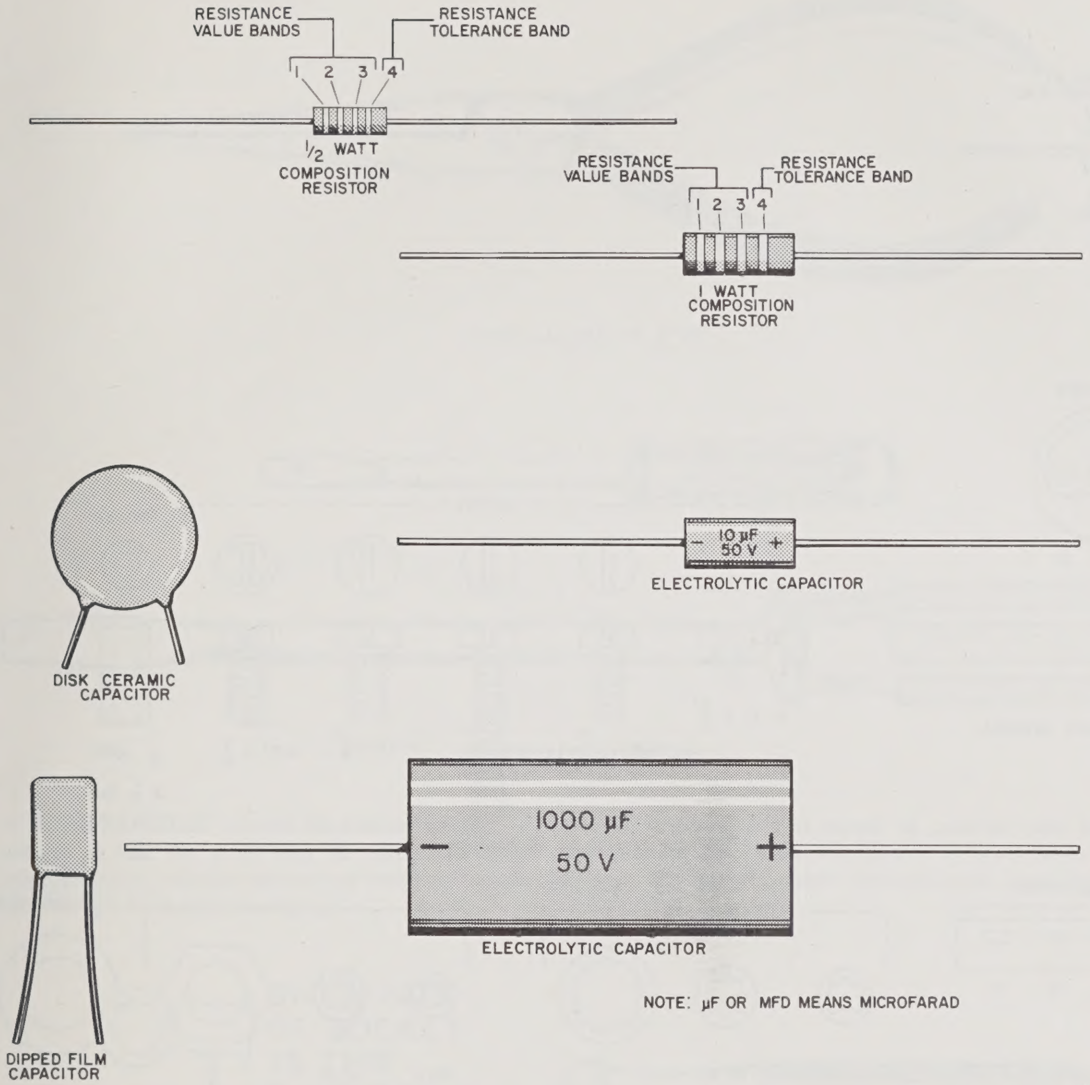
SELECTION AND USE OF TOOLS

For the construction described in this manual (and for general use later), you will need the following tools:

Pair of Long-Nose Pliers
Pair of Wire Cutters (Small Diagonal Type)
Screwdriver (Blade ¼″ by 6″)
Screwdriver (Blade ⅛″ by 3″)
Nut Driver (¼″ Hex. Socket)
Low-Wattage Soldering Iron
Small Wire Stripper (Optional)

Use the proper tools, and work carefully. Take care to avoid mechanical damage to screws and nuts and other parts, and unsightly scratches that may be difficult to cover up. Figure 4 (at the end of this section) gives useful information about tools and their use.

A good job of assembly and wiring produces a neat and trouble-free product. Be especially careful when stripping and soldering wires. Poorly soldered joints cause hard-to-find troubles. Nicked wires may break long after they are installed. Loose strands and loose ends of wire may cause short circuits and, as a result, damage other components.



NOTE: µF OR MFD MEANS MICROFARAD

Figure 1

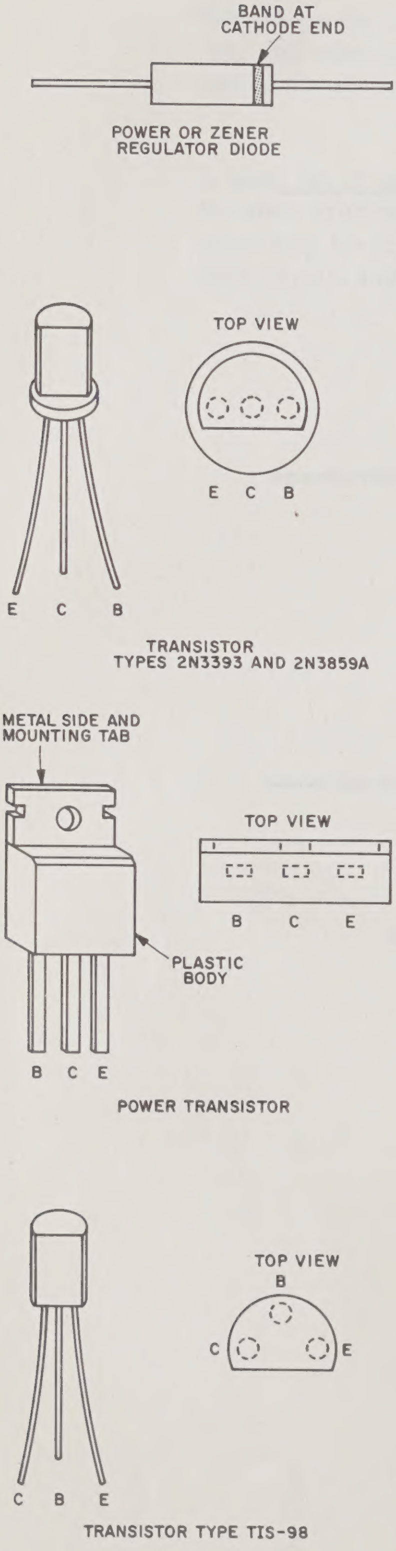


Figure 2

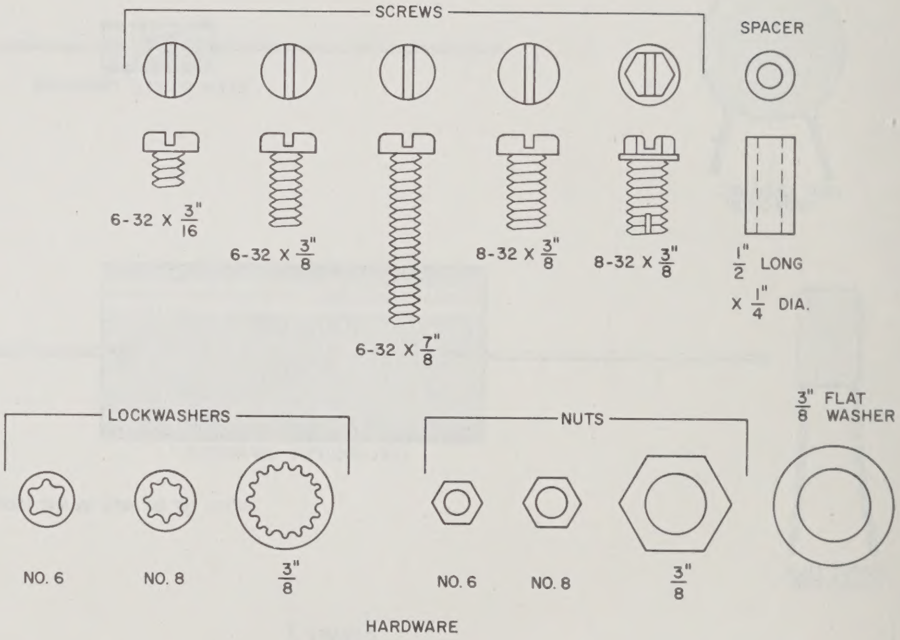
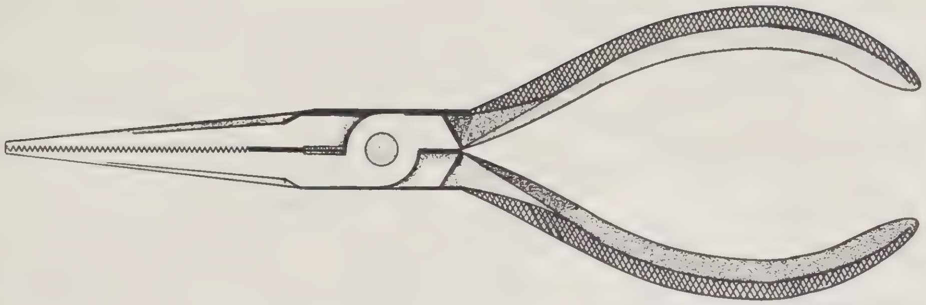
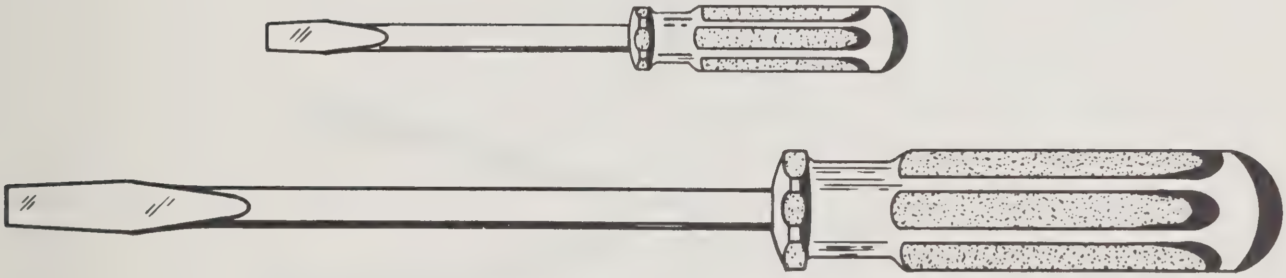


Figure 3

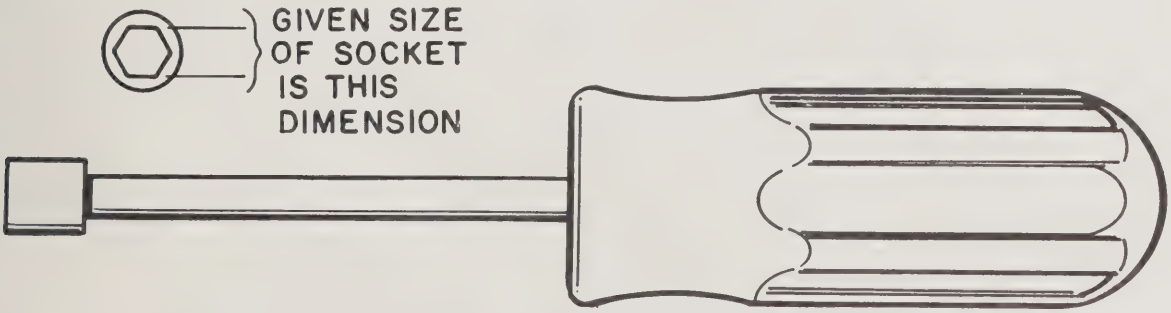


LONG-NOSE PLIERS



SCREWDRIVERS

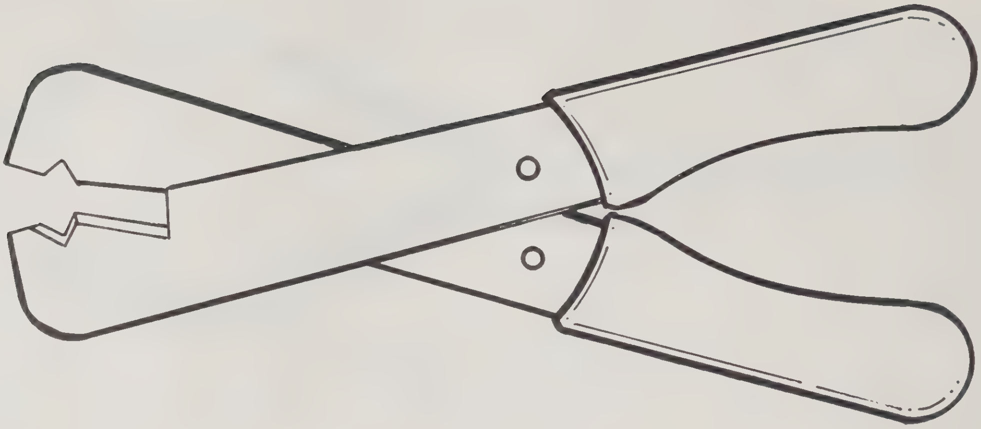
A SCREWDRIVER should be selected so that its blade fits a screw slot as snugly as possible, and is wide enough so that the screw may be tightened without damaging the slot. When the squared-off screwdriver blade edges become rounded because of wear or misuse, they may slip out of a screw slot and cause damage to the screw or piece of equipment.



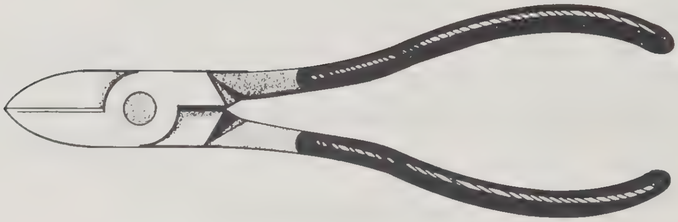
SOCKET-HEAD
NUT DRIVER

A SOCKET-HEAD NUTDRIVER is easy to use in a restricted space, and it may be used to hold a nut while a screw is tightened. If the proper size of socket is used, the socket will not slip off a nut and possibly mar a nearby surface. For that reason a ¼″ nutdriver could be used to tighten the hex-head screws which attach the side panels to the design console.

Figure 4



WIRE STRIPPERS



WIRE-CUTTERS

WIRE CUTTERS permit the cutting of wires close to a terminal, or the cutting of projecting component leads close to a circuit board. They are intended for cutting copper wire, insulation and similar soft materials; and will be damaged by cutting screws, steel wire, or other hard materials.

Figure 4

MATERIALS FOR PROJECT 1

1—Metal Chassis

1—Power Transformer

4—Modular Design Panels (2 from Basic Design Console)

3—Modular Connectors (from Basic Design Console)

1—Rotary Switch

1—Black Knob

1—Fuse Block

1—Fuse (1 Ampere)

1—Line Cord

1—Line Cord Bushing ?

4—Rubber Feet

2—½″ Grommets

8—6-32 × 3/16″ Screws

1—6-32 × ⅜″ Screw

2—8-32 × ⅜″ Screws

1—No. 6 Lockwasher

2—No. 8 Lockwashers

1—⅜″ Lockwasher

1—⅜″ Flat Washer

1—6-32 Nut

2—8-32 Nuts

1—⅜″ Nut

5 Feet of Green Wire
5 Feet of Brown Wire
6 Feet of Solder

PROJECT 1

CONSTRUCTION OF DESIGN CONSOLE — STAGE 1

DISCUSSION

This construction project will bring the design console to the stage shown in Figure 1-1. Note that at this stage it will consist of the metal chassis, the complete set of 4 modular design panels, a line cord, fuse block with fuse, line switch, and power transformer. Low-voltage ac is available at 3 modular connectors for the experiments which you will do after this stage of construction.

Find a comfortable place to work, with adequate space, sufficient light and the least amount of distraction. If you do this, you will find it easier to do the construction projects and the experiments performed with this equipment.

PROCEDURE

(_____) **Step 1**

PARTS NEEDED

1—Metal Chassis	4—Rubber Feet

Place the chassis upside down on a magazine, cloth, or paper. This will avoid scratching the chassis or your table. Peel the backing from the rubber feet and attach them to the front and rear flanges. As shown in Figure 1-2, they are positioned at the edges of the chassis and centered over the holes in the side mounting tabs on the other side of the chassis. After the rubber feet are attached, turn the chassis right side up.

(_____) **Step 2**

PARTS NEEDED

4—Modular Design Panels	8—6-32 × 3/16″ Screws

Place the chassis with the short front flange toward you. Interlock the four panels with the lettering all on the same side. Place the panels on the design console as shown in Figure 1-2.

Figure 1-2 shows the location of the eight screw holes on the design panels. Find hole "G4" on the upper left panel section, and line it up with the hole nearby in the chassis. From below the chassis, insert one short screw and partly tighten it in hole G4. At the opposite corner, from below the chassis, put in another screw through hole "G12." Then insert the other 6 screws. Firmly tighten all 8 screws, but do not overtighten them.

(_____) **Step 3**

PARTS NEEDED

1—Rotary Switch	1—3/8″ Flat Washer
1—Black Knob	1—3/8″ Nut
1—3/8″ Lockwasher	

If the rotary switch has a "locating tab" which would keep it from being mounted flush against the chassis, carefully break off the tab with your pair of long-nose pliers. Place the lockwasher on the switch bushing as shown in Figure 1-3. Insert the switch with lockwasher through the hole in the front of the chassis from below the chassis as shown in Figure 1-3. Place the flat washer and nut on the switch bushing and turn "finger tight." Position the switch terminals as shown in Figure 1-4, and "finger tighten" the nut. Install the black knob on the shaft, with its setscrew tightened against the flat side of the shaft.

(_____) **Step 4**

PARTS NEEDED

1—Fuse Block	1—No. 6 Lockwasher
1—6-32 × 3/8″ Screw	1—6-32 Nut

Check Figure 3 in the General Information section for the size and shape of the hardware needed. Mount the fuse block as shown in Figure 1-5. Its position on the chassis is shown in Figure 1-2. Tighten the screw just to the point of being snug, because the fuse block will be positioned later for easier soldering.

(_____) **Step 5**

PARTS NEEDED

1—Power Transformer	2—No. 8 Lockwashers
2—8-32 × 3/8″ Screws	2—8-32 Nuts

Mount the transformer as shown in Figure 1-2, with the screw heads below the chassis. The lockwashers are placed between the transformer bracket and the nuts. Note that the transformer is positioned so that the terminal lugs are toward the rear of the chassis.

(_____) **Step 6**

PARTS NEEDED

1—Line Cord	1—Line Cord Bushing

Refer to Figure 1-6. Split the line cord conductors for 3″. Do not cut into or expose the wire in the conductors. Strip off ¼″ of insulation from the split end of the conductors. Be careful not to nick or cut the strands of wire.

Slip the bushing around the line cord with the smaller end of the bushing toward the separated ends of the wire, as shown in Figure 1-6, and 3½″ back from the ends of the wire. Compress the bushing around the line cord. From below the chassis, insert the line cord up through the "double-D" hole shown in Figure 1-2, and push the bushing until it snaps into position. You may need your long-nose pliers to compress and insert the bushing.

This bushing insulates the line cord from the metal chassis and also securely clamps it, so that it cannot be pulled out and thereby damage a terminal or component.

(_____) **Step 7**

PARTS NEEDED

2—Rubber Grommets

Slide these into the chassis slots, into the positions shown in Figure 1-2. These grommets are used to protect the wiring which passes through the chassis.

(_____) **Step 8**

PARTS NEEDED

3—Modular Connectors	5 Feet of Green Wire
5 Feet of Brown Wire	6 Feet of Solder

Before beginning this step, read SOLDERING (Supplement 0208). Proper operation of this piece of equipment requires properly soldered connections.

Before soldering plastic-insulated wire at any terminal, bring the wire straight away (without any bends) from the terminal for at least one inch. When a soldered connection is made near a bend, the heated plastic insulation tends to pull away from the wire. After the soldered wire has cooled, it may be bent as needed.

Cut two lengths of brown wire 24″ long. Cut three lengths of green wire, each 13″ long. Strip ¼″ of insulation from both ends of each of the five wires.

Twist the stripped ends of the line cord to gather up any loose strands and "tin" these ends. The "tinning" process is explained in Supplement 0208, SOLDERING. When "tinning" the wire, the solder should saturate all strands. Remove any excess solder by gently tapping the wire before the solder hardens.

Turn the fuse block sufficiently so that you can solder the terminal nearest the transformer. Insert one end of the line cord up through that terminal almost to the insulation, position the protruding tinned end toward the transformer, and solder. See Figure 1-7. Do not use too much solder or allow it to run down into the fuse clip. Clip off the excess wire above the terminal. After the wire and fuse holder have cooled, turn the fuse holder back to the position shown in Figure 1-7 and tighten the mounting screw.

Bring one brown wire up through the other fuse block terminal, with the wire protruding through the terminal pointing to the left. Wrap the wire counterclockwise around the terminal, crimp lightly, and solder.

Figure 1-7 identifies all of the transformer terminals. Place one end of the other brown wire against the left side of transformer Terminal 6, wrap it around the lug from behind, crimp lightly, and solder. Make sure that this wire does not touch any of the other terminals.

Thread these two brown wires with hand-formed square bends through the two grommets, then double them back around the front grommet and over to the switch. (See Figure 1-8.) This switch will be moved later to the outside front panel of the design console, which is why the wires are temporarily routed in this manner. Connect the brown wire from the fuse to terminal 2 of the switch (see Figure 1-4) and solder. Connect the brown wire connected to the transformer to terminal 1 of the switch and solder. If necessary, remove the knob, loosen the mounting nut and rotate the switch slightly for ease of soldering. Then return the switch to the position shown in Figure 1-4, tighten the mounting nut and replace the knob.

Connect the other line cord wire to transformer Terminal 7. Bend it into a short "U," hook it on from the left side, as you face the terminals, crimp lightly, and solder.

Connect the three green wires to transformer Terminals 2, 5, and 10 in the same way as you connected the other wires to the transformer (see Figure 1-9) and solder them. Route the wires to the left, from behind the lugs, as shown in Figure 1-7. Plug in 3 modular connectors and insert the free ends of these three green wires as shown in Figure 1-9.

From Transformer Terminal No.	*To Modular Connector No.*
2	5
10	4
5	3

These leads are now connected to the secondary winding of the transformer that supplies 12.6 volts, center-tapped, at a 1 ampere load.

Carefully inspect this wiring. Is there good clearance around each terminal? Is there a possibility of shorting out any of the circuit if the wires are moved? If necessary, reposition the wires for better clearance.

(_____) **Step 9**

PART NEEDED

1—Fuse (1 Ampere)

Insert the fuse. Turn the switch all the way to the left. This turns the unit off. With your meter on the high-ohms resistance range, measure the resistance from the chassis to one line cord prong. (The setscrew on the switch knob should be used as chassis ground, since the chassis is painted.) Then measure from the chassis to the other line cord prong. You should read infinite resistance both times. Now measure the resistance between the line cord prongs (one ohmmeter lead connected to each cord prong), still in the "high ohms" position. You should still read infinite resistance. Now switch to the lowest resistance range, still measuring between the line cord prongs. Turn the switch knob one position clockwise (to the right). You should now read about 17 ohms. Turn the design console switch to the next position to the right (next clockwise position). The resistance should remain the same. In the last two switch positions, you are measuring the resistance of the primary winding, plus the very small fuse and wiring resistance.

If your measurements are much different than these, recheck your wiring. Significantly different readings indicate that something is wrong. DO NOT CONTINUE until the correct readings are obtained.

Such measurements should always be made on any line-operated equipment which you build—before you connect the plug to an ac outlet.

Before plugging in the line cord for final testing, put a piece of electrical tape or masking tape over the fuse block and its terminals. Do not touch transformer primary Terminals 6 and 7 when the design console is turned ON because these terminals carry line voltage and can give you an electrical shock.

Turn the switch OFF and plug in the line cord. Turn the switch to one of the ON positions. Measure the ac voltage between modular connectors 3 and 5. With no load and normal line voltage, you should measure about 14.5 volts. Do not measure voltages at the transformer terminals.

The initial construction and testing are now finished. Remove the line cord plug from the electric outlet when you are not using this design console. Store the design console in a safe place until you are again ready to use it.

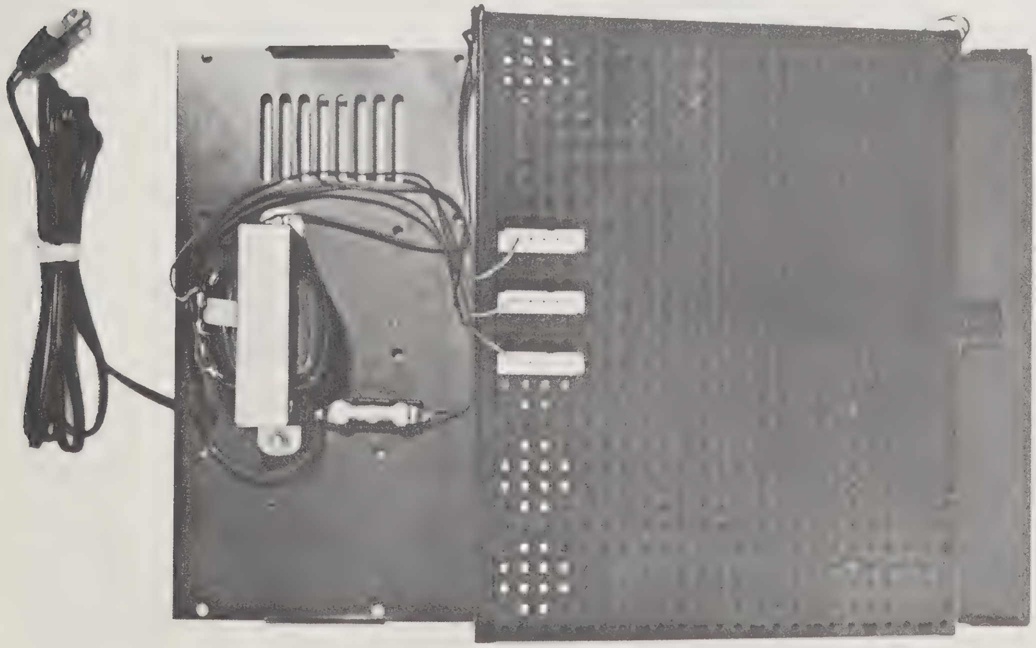


Figure 1-1

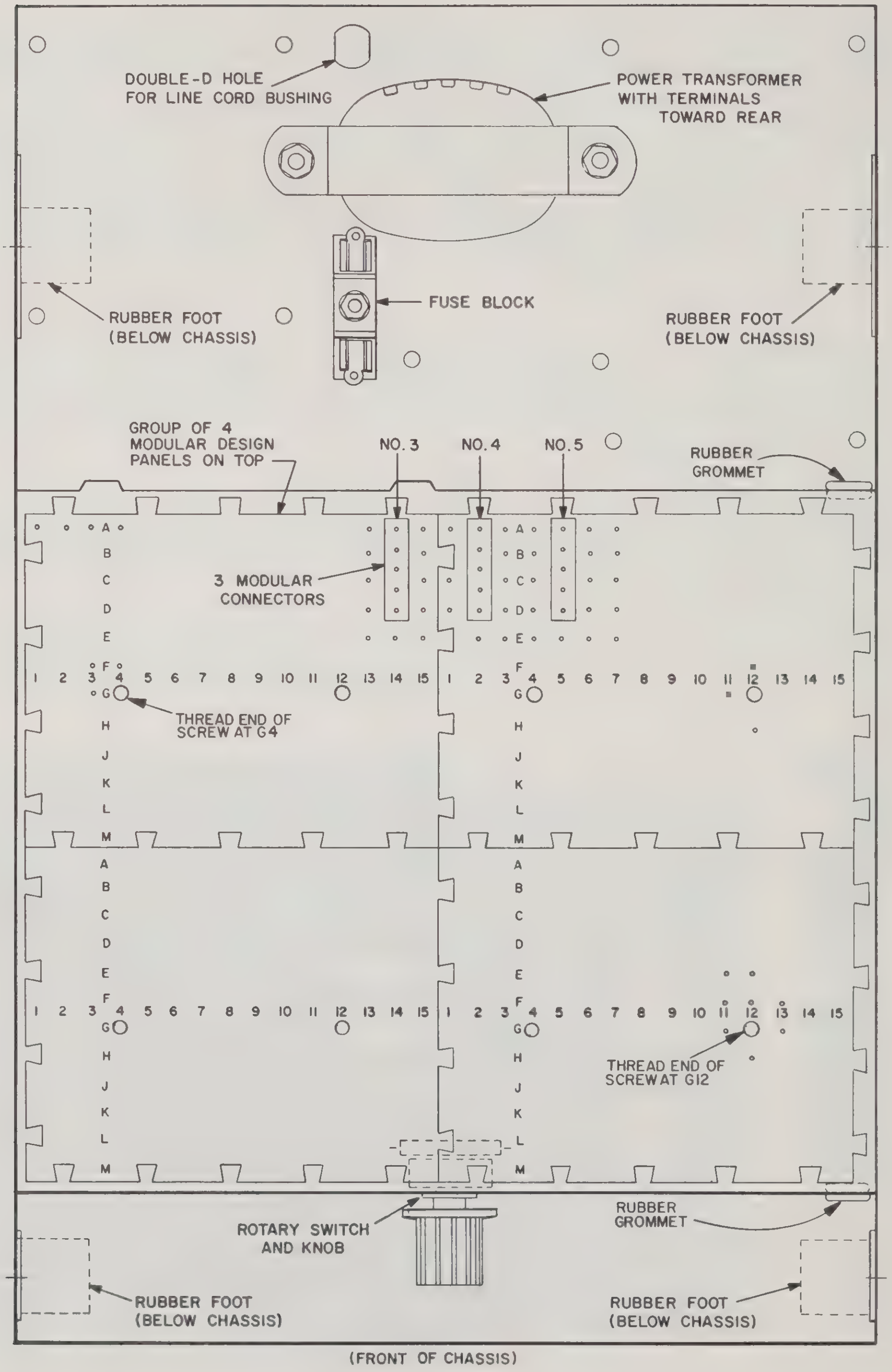

DOUBLE-D HOLE FOR LINE CORD BUSHING
POWER TRANSFORMER WITH TERMINALS TOWARD REAR
FUSE BLOCK
RUBBER FOOT (BELOW CHASSIS)
RUBBER FOOT (BELOW CHASSIS)
GROUP OF 4 MODULAR DESIGN PANELS ON TOP
NO. 3
NO. 4
NO. 5
RUBBER GROMMET
3 MODULAR CONNECTORS
THREAD END OF SCREW AT G4
A
B
C
D
E
F
G
H
J
K
L
M
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
THREAD END OF SCREW AT G12
ROTARY SWITCH AND KNOB
RUBBER GROMMET
RUBBER FOOT (BELOW CHASSIS)
RUBBER FOOT (BELOW CHASSIS)
(FRONT OF CHASSIS)

Figure 1-2

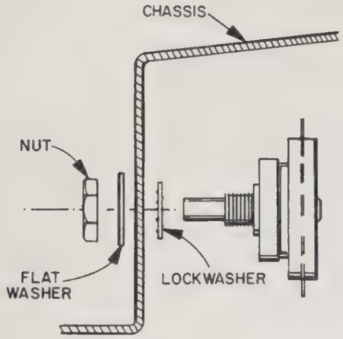


Figure 1-3

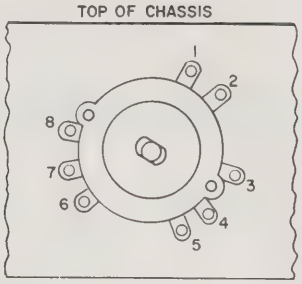


Figure 1-4

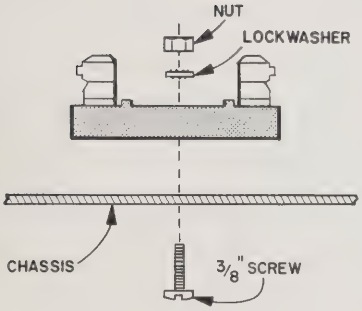


Figure 1-5

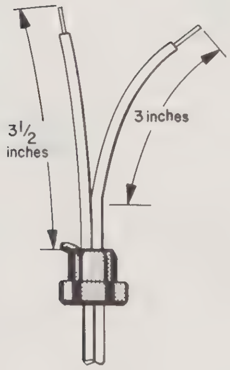


Figure 1-6

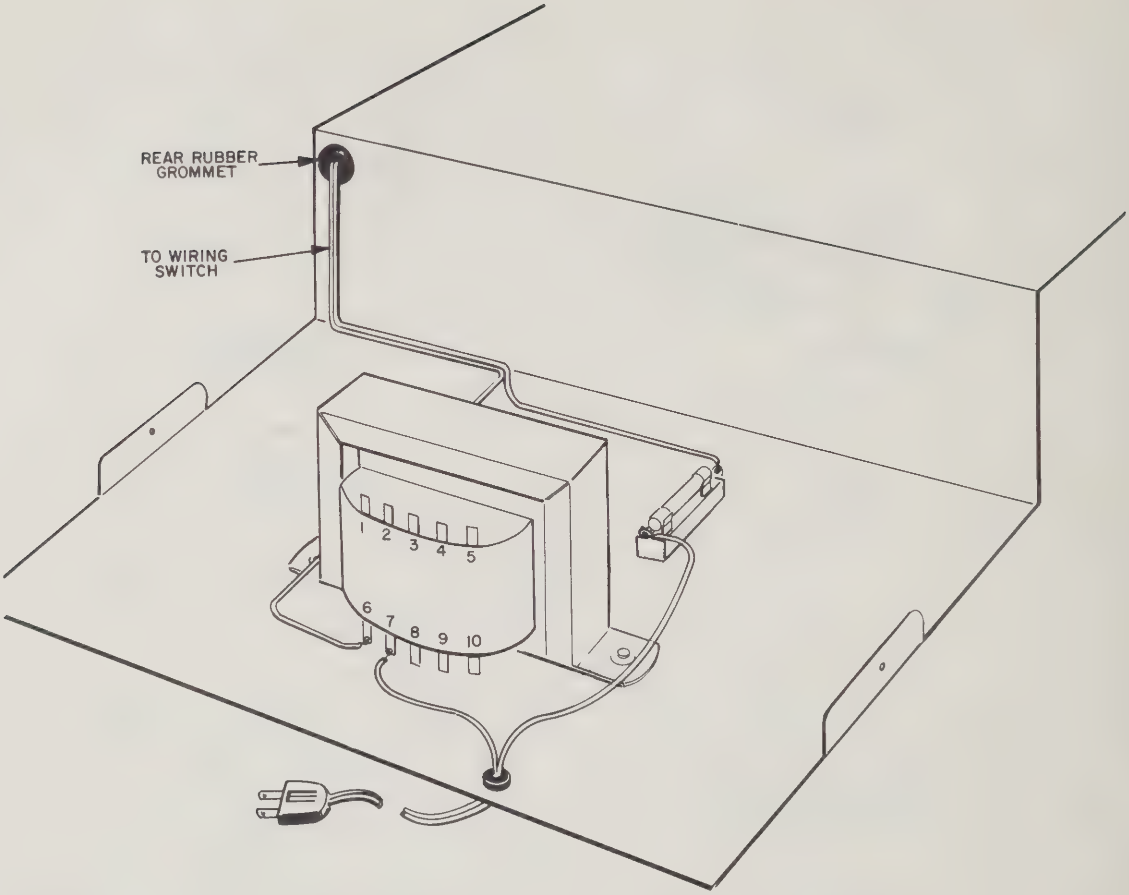


Figure 1-7

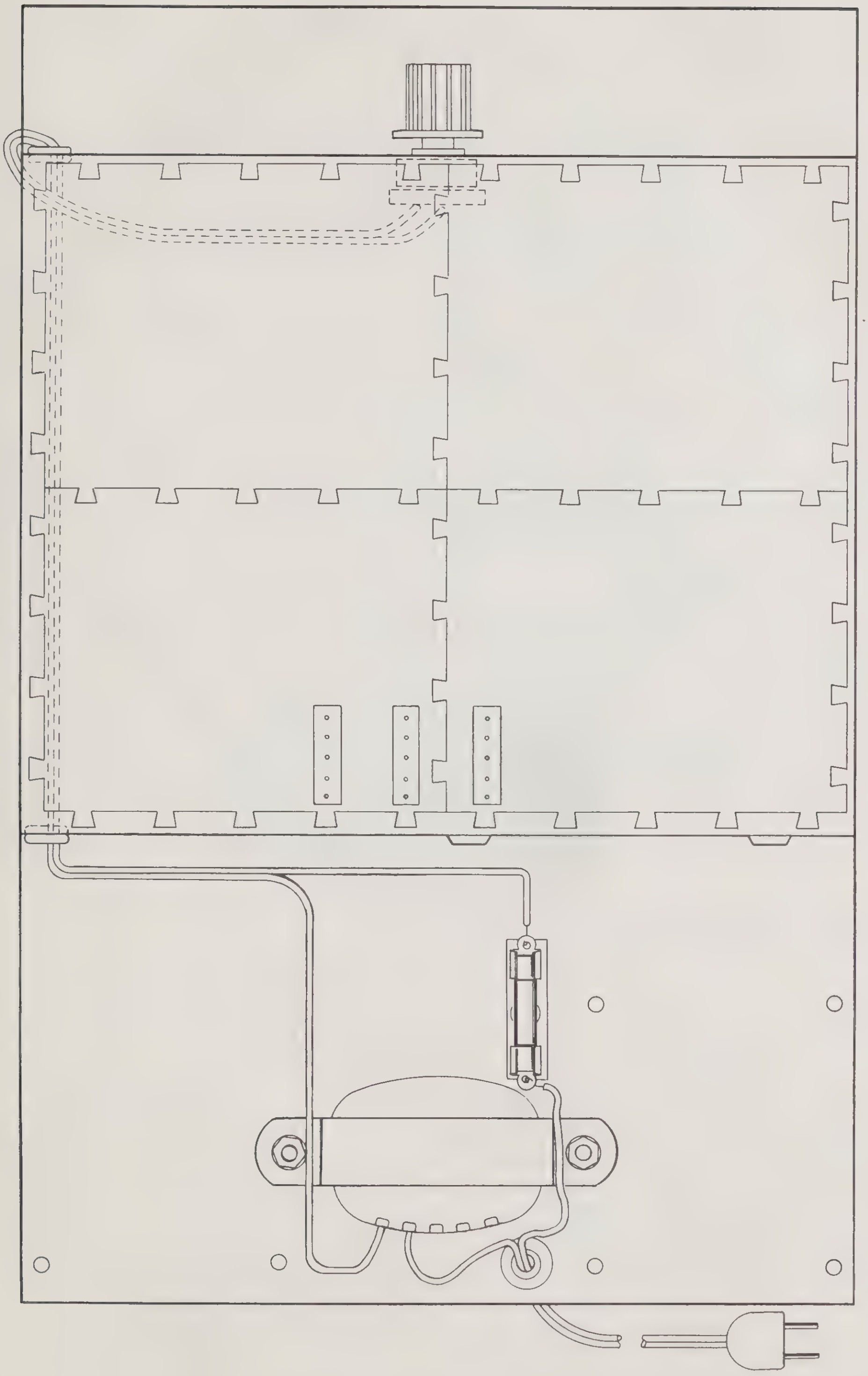


Figure 1-8

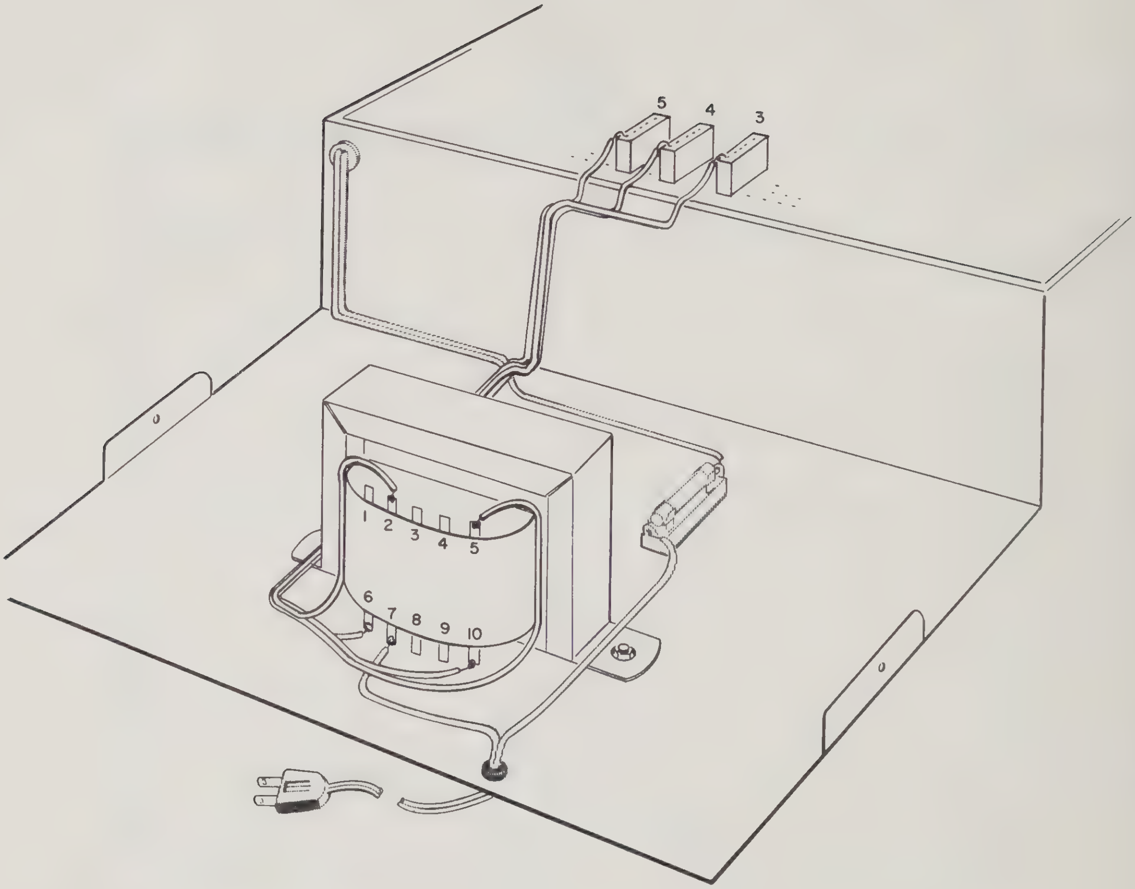


Figure 1-9

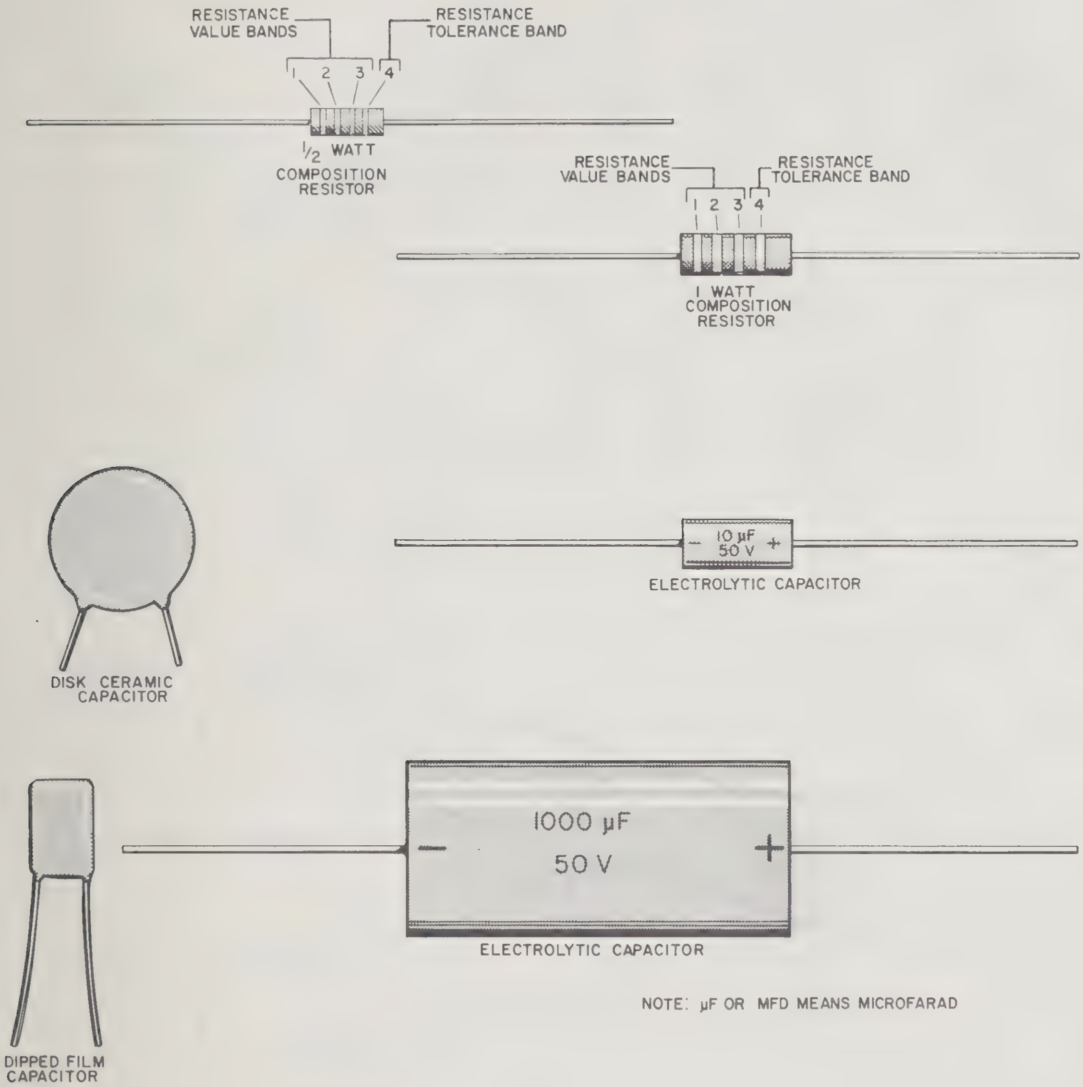


Figure 1

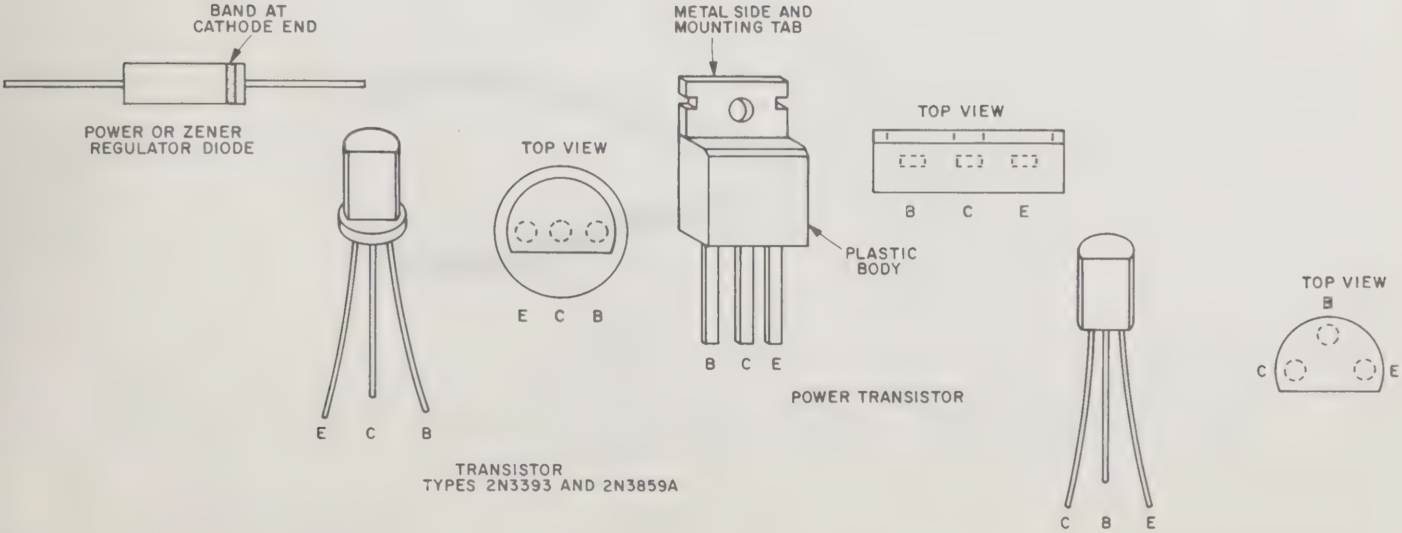


Figure 2

TRANSISTOR TYPE TIS-98

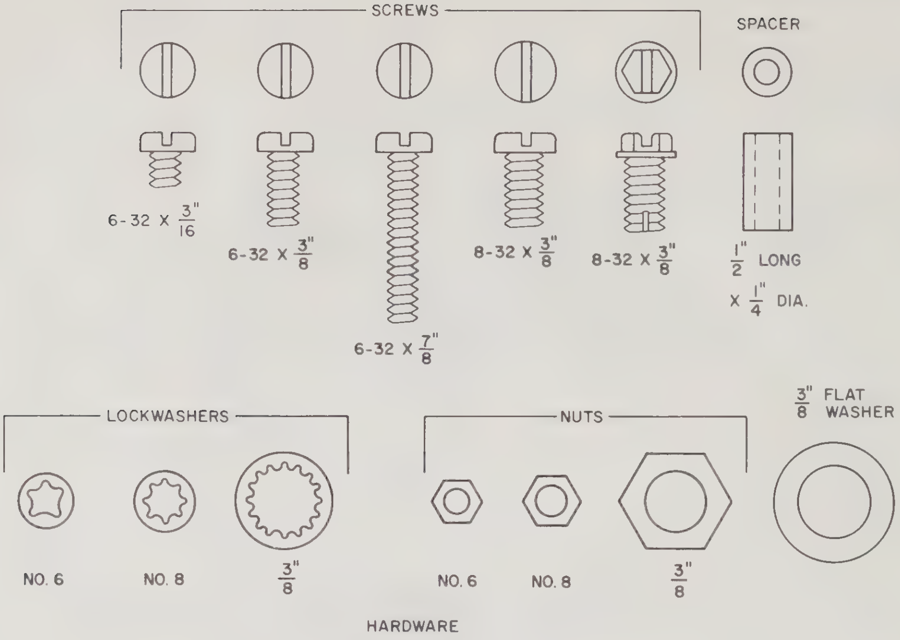
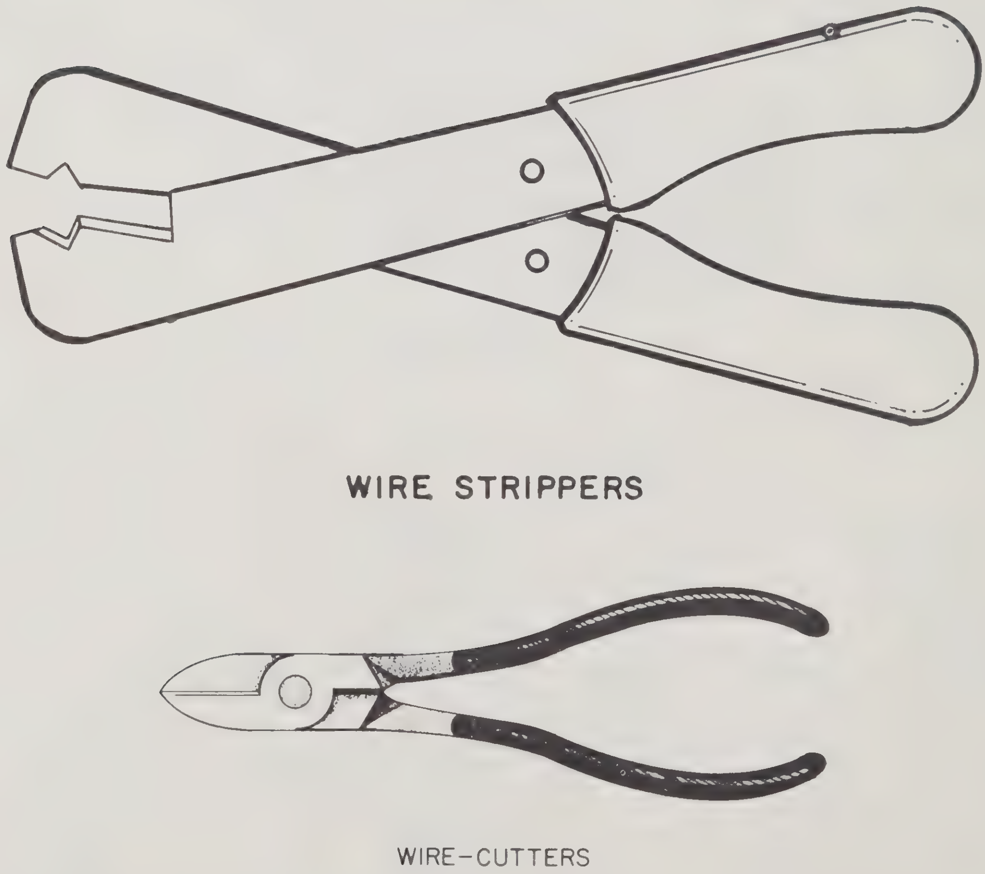


Figure 3



WIRE CUTTERS permit the cutting of wires close to a terminal, or the cutting of projecting component leads close to a circuit board. They are intended for cutting copper wire, insulation and similar soft materials; and will be damaged by cutting screws, steel wire, or other hard materials.

Figure 4

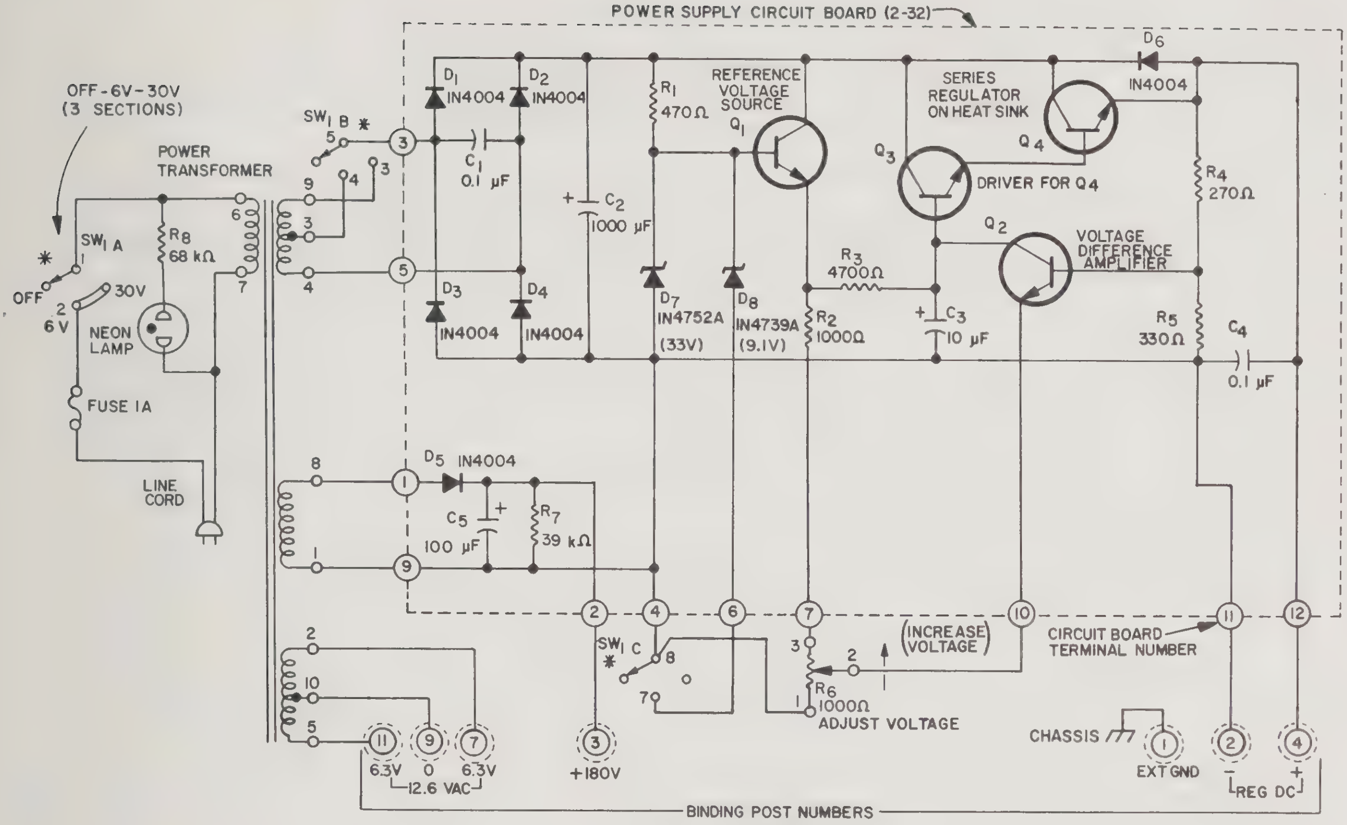

POWER SUPPLY CIRCUIT BOARD (2-32)
OFF-6V-30V
(3 SECTIONS)
SW1 A
OFF
6 V
30V
R8
68 kΩ
NEON LAMP
FUSE 1A
LINE CORD
POWER TRANSFORMER
SW1 B
D1 1N4004
D2 1N4004
D3 1N4004
D4 1N4004
C1 0.1 µF
C2 1000 µF
R1 470 Ω
REFERENCE VOLTAGE SOURCE
Q1
D7 1N4752A (33V)
D8 1N4739A (9.1V)
R2 1000Ω
R3 4700Ω
C3 10 µF
SERIES REGULATOR ON HEAT SINK
Q3
DRIVER FOR Q4
Q4
D6 1N4004
Q2
VOLTAGE DIFFERENCE AMPLIFIER
R4 270Ω
R5 330Ω
C4 0.1 µF
D5 1N4004
C5 100 µF
R7 39 kΩ
SW1 C
(INCREASE VOLTAGE)
R6 1000Ω
ADJUST VOLTAGE
CIRCUIT BOARD TERMINAL NUMBER
CHASSIS
EXT GND
6.3V
0
6.3V
12.6 VAC
+180V
REG DC
BINDING POST NUMBERS

Figure 4-1

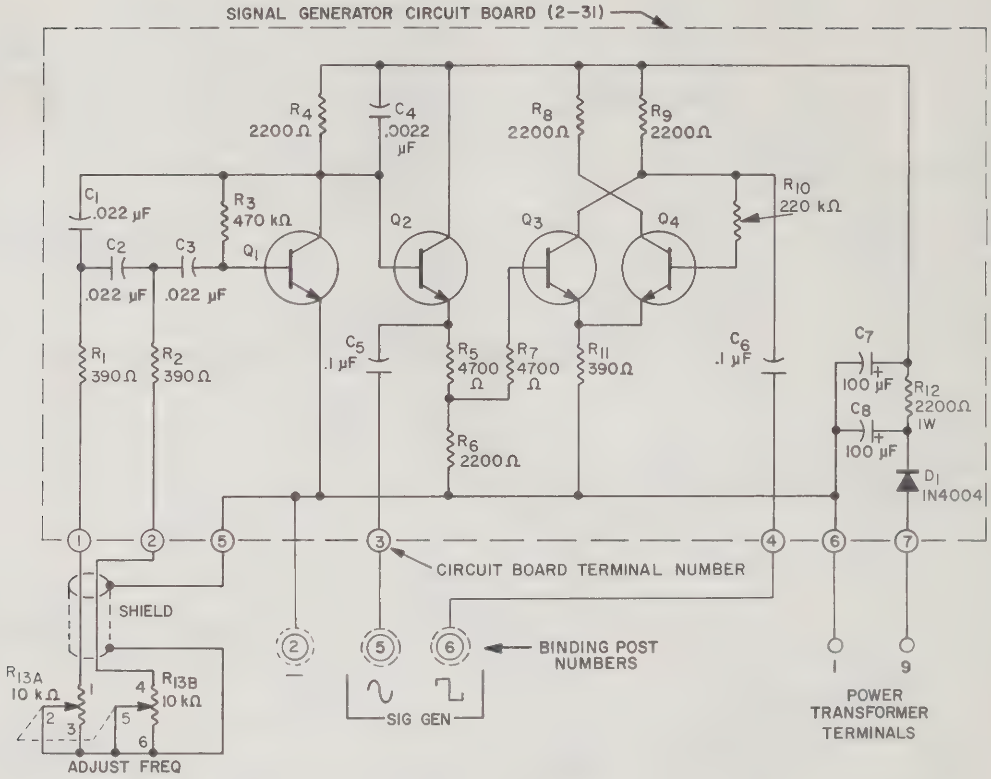


Figure 4-2

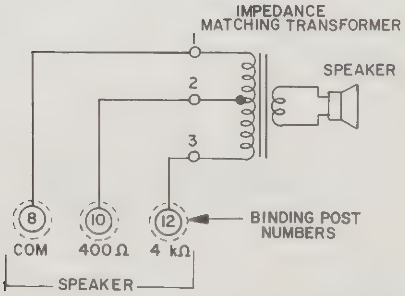


Figure 4-3

MATERIALS FOR PROJECT 2

1—Design Console, Stage 1

1—Circuit Board (Part No. 2-32)

1—470Ω, ½ W, 10% Resistor

1—4700Ω, ½ W, 10% Resistor

1—270Ω, 1 W, 10% Resistor

1—330Ω, 1 W, 10% Resistor

1—1000Ω, 1 W, 10% Resistor

1—39 kΩ, 1 W, 10% Resistor

1—1000Ω Potentiometer

2—0.1 μF Disk Capacitors

1—10 μF Electrolytic Capacitor

1—100 μF Electrolytic Capacitor

1—1000 μF Electrolytic Capacitor

1—1N4739A Zener Diode

1—1N4752A Zener Diode

6—1N4004 Diodes

3—2N3859A or TIS-98 Transistors

1—2N5294 Power Transistor

3—Modular Connectors (From Previous Shipment)

1—Aluminum Heat Sink

1—Package Heat Sink Grease

1—Black Knob

1—6-32 × ⅜″ Screw

4—6-32 × ⅞″ Screws

4—No. 6 × ½″ Spacers

4—No. 6 Lockwashers

1—No. 6 Solder Lug

5—6-32 Nuts

1—⅜″ Lockwasher

1—⅜″ Flat Washer

1—⅜″ Nut

6 Feet of Black Wire

5 Feet of Red Wire

7 Feet of Yellow Wire

6 Feet of Blue Wire

4 Feet of White Wire

6 Feet of Solder

PROJECT 2

CONSTRUCTION OF DESIGN CONSOLE — STAGE 2

DISCUSSION

This construction project will bring the design console to the stage shown in Figure 2-1. Note that at the end of this stage it will consist of the metal chassis, the complete set of 4 modular design panels, the power transformer and other parts and wiring installed in Project 1, with an added circuit board, control potentiometer, modular connector terminals and wiring. Regulated dc power is available at the 2 added left-hand modular connectors, and high-voltage unregulated dc power is available at the right-hand modular connector. These voltage sources will be required for the experiments which you will do after the completion of Project 2.

Since circuit board assembly requires a rather special procedure, make sure that you understand the instructions that follow. They will be helpful for any circuit board assembly that you may undertake later.

1. If the circuit board foil conductors seem hard to solder, clean the terminal areas with a pencil eraser. If the terminal areas on the conductor side of the board have a lacquer-like coating, cleaning should not be necessary.

2. Clean the component leads with a small piece of fine sandpaper to insure easy soldering.

3. Bend component leads to fit the spacing of the holes in the circuit board. Sharp, square bends are not recommended. A simple bending jig cut from stiff cardboard or plastic can be used. For the ½-watt resistors and all diodes, cut a jig 9/16″ by 3″. The three-inch dimension is for ease in holding. For the 1-watt resistors, cut a jig ⅞″ by 3″. To use the bending jig, center the component on it and bend the leads down over the edges of the jig.

4. Mount labeled components so that their values or part numbers will be visible after mounting.

5. Be sure of the polarity of diodes, zener diodes, electrolytic capacitors or other components that show polarity before you insert them into the board. Be sure that transistors or other semiconductor devices are properly inserted into a board or socket.

6. Mount color-coded resistors or capacitors so that their color-coding is read in the same horizontal or vertical directions.

7. Several components may be inserted into the board, held captive by spreading their leads, and soldered, all in one group.

8. Don't overheat the connections when soldering. Keep the hot soldering iron tip clean and well-tinned to make the solder flow quickly. When the solder flows, use just enough to encircle the lead wire. Wipe excess solder from the tip of the iron. Be especially careful where leads are close together to avoid accidental short circuits.

9. After soldering, immediately inspect the connections. If any holes show around a lead wire, or if the solder appears dull, whitish or irregular, resolder that connection. Then clip off the leads one at a time.

10. To hold the circuit board for easier soldering, it may be set across a small open box which provides clearance for the parts already installed.

11. Put the design console aside while soldering the circuit boards and while soldering the internal wiring of the design console. This insures that the plastic modular design panels cannot be damaged by the soldering iron tip or by molten solder.

PROCEDURE

(✓) Step 1

PARTS NEEDED

1—Circuit Board (Part No. 2-32)
1—1N4739A Zener Diode
1—1N4752A Zener Diode
—Solder

Observe the polarity of these diodes. As they are inserted into the board, position them so that their identifying bands (cathodes) are as shown in Figure 2-2 and on the component side of the circuit board. THE COMPONENT SIDE OF THE BOARD SHOWS THE POSITION OF THE COMPONENTS BY THEIR OUTLINES, PART NUMBERS, VALUES AND POLARITIES.

Insert the 1N4739A Zener diode with the polarity as shown at $\mathbf{D}_8$. ($\mathbf{D}_8$ indicates where the diode is placed on the circuit board. This designation appears both on the COMPONENT side of the circuit board and in Figure 2-2.) Insert the 1N4752A Zener diode with the polarity as shown at $\mathbf{D}_7$. Solder these four connections, inspect the connections and clip off the excess projecting leads from the foil side of the board.

(✓) **Step 2**

PARTS NEEDED

3—1N4004 Diodes
—Solder

Observe the polarity of these diodes. Insert them at $\mathbf{D}_1$, $\mathbf{D}_3$ and $\mathbf{D}_5$. Solder these six connections, inspect the connections and clip off the excess projecting leads from the foil side of the board.

(✓) **Step 3**

PARTS NEEDED

3—1N4004 Diodes
—Solder

Observe the polarity of these diodes. Insert them at $\mathbf{D}_2$, $\mathbf{D}_4$ and $\mathbf{D}_6$. Solder these six connections, inspect the connections and clip off the excess projecting leads from the foil side of the board.

(✓) **Step 4**

PARTS NEEDED

1—39 kΩ, 1 W, Resistor
1—4700Ω, ½ W, Resistor
1—470Ω, ½ W, Resistor
—Solder

Insert the 39 kΩ resistor at $\mathbf{R}_7$, the 470Ω resistor at $\mathbf{R}_1$, and the 4700Ω resistor at $\mathbf{R}_3$. Solder these six connections. Inspect the connections and clip off the excess projecting leads.

(✓) **Step 5**

PARTS NEEDED

1—1000Ω, 1 W, Resistor
1—270Ω, 1 W, Resistor
1—330Ω, 1 W, Resistor
—Solder

Insert the 1000Ω resistor at $\mathbf{R}_2$, the 330Ω resistor at $\mathbf{R}_5$, and the 270Ω resistor at $\mathbf{R}_4$. Solder these six connections. Inspect them and clip off the excess projecting leads.

(X) **Step 6**

PARTS NEEDED

2—0.1 μF Disk Capacitors —Solder

1—10 μF Electrolytic Capacitor

Insert the disk capacitors at **C_1** and **C_4**. If the coating on the disk capacitors is broken or cracked at the leads, they are still all right. Insert the 10 μF electrolytic capacitor at **C_3** with the polarity as shown. Solder these six connections and inspect them. Clip off the excess projecting leads.

(X) **Step 7**

PARTS NEEDED

3—2N3859A (or —Solder
    3—TIS-98) Transistors

Mount one transistor at **Q_1**, as shown in Figure 2-2. Spread its leads (as shown in Figure 2-3) so that they enter the terminal mounting holes. Push the transistor down upon the board until its bottom surface is ¼″ above the board. Slightly spread the transistor leads below the board if required to keep it in position for soldering. Solder the three connections and inspect them carefully. Clip off the excess projecting leads. Be sure that this transistor is correctly installed, as shown in Figure 2-3. (This figure shows the basing diagram for both the 2N3859A and TIS-98 transistors.) In the same manner, install the others at **Q_2** and **Q_3**.

(X) **Step 8**

PARTS NEEDED

1—100 μF Electrolytic Capacitor —Solder

1—1000 μF Electrolytic Capacitor

Mount the 100 μF capacitor at **C_5**, as shown in Figure 2-2. Be sure that the polarity is correct. Curve the leads by hand. Mount this capacitor so that the value marking is easily visible. In the same manner, mount the 1000 μF capacitor at **C_2**. Solder these four connections and inspect them. Clip off the excess projecting leads.

(X) **Step 9**

PARTS NEEDED

1—2N5294 Transistor

1—Aluminum Heat Sink

1—Package Heat Sink Grease

1—6-32 × ⅜″ Screw

1—No. 6 Lockwasher

1—6-32 Nut

—Solder

Put a thin coat of heat sink grease on the metal side of the transistor. If the heat sink is notched, mount the transistor to it with the leads toward the notch, as shown in Figure 2-4. Insert the screw through the heat sink and then through the transistor. Add the lockwasher and nut and tighten the screw securely. The edges of the transistor should be parallel with the bends in the heat sink.

Mount the transistor and heat sink assembly at $\mathbf{Q_4}$, as shown in Figure 2-2. Carefully bend the center lead so that all three leads will enter the circuit board holes from the component side and protrude through the copper side. While pressing the heat sink firmly against the board, solder these three connections. The heat sink outline, shown at $\mathbf{Q_4}$ on the top of the board, indicates the approximate position of the transistor and heat sink assembly. Position the heat sink so the outer leads of $\mathbf{Q_4}$ are straight.

(X) **Step 10**

PART NEEDED

1—Partially Completed Circuit Board

Inspect all soldered connections. Be sure that the transistor terminals are not accidently short-circuited by solder. Inspect the power transistor leads on the top of the board at $\mathbf{Q_4}$ to see if they are well separated from the heat sink, if the heat sink is not notched. If the leads appear to be very close to the heat sink, carefully move the heat sink for about 1/16″ clearance.

(X) **Step 11**

PARTS NEEDED

Wire (as shown below)

—Solder

Connecting wires must be soldered to the circuit board input and output terminals before the board can be mounted to the chassis. Cut each wire to the length shown in the table below, and strip ¼″ of insulation from both ends of each wire. Insert one end of each wire (in the order given below) through the board FROM the component side. Solder each wire to the board, one at a time, and clip off the excess projecting wire. Carefully inspect each connection, as before. You may want to check them off, one at a time, as you solder them.

Color	*Length, Inches*	*To Circuit Board Terminal Number*
White	7	1
Red	18	2
Red	22	3
Black	22	4
Yellow	7	5
White	24	6
Blue	23	7
	(Terminal 8 is not used)	
Black	4	9
Yellow	24	10
Black	15	11
Yellow	15	12

☒ **Step 12**

PARTS NEEDED

1—1000Ω Potentiometer

1—⅜″ Lockwasher

1—⅜″ Flat Washer

1—⅜″ Nut

1—Black Knob

If the potentiometer has a "locating tab" which would keep it from being mounted flush against the chassis, carefully bend the tab outward with your long-nose pliers. Place the lockwasher on the potentiometer bushing. From below the chassis, insert the potentiometer and lockwasher through the hole next to the switch already installed. This is shown in Figure 2-5. Place the flat washer and nut on the bushing. Position the potentiometer terminals as shown in the figure and tighten the nut. Install the black knob on the shaft with its setscrew tightened against the flat side of the shaft.

(✓) **Step 13**

PARTS NEEDED

1—Assembled Circuit Board
with Attached Lead Wires

4—6-32 × ⅞″ Screws

4—No. 6 × ½″ Spacers

3—No. 6 Lockwashers

1—No. 6 Solder Lug

4—6-32 Nuts

The circuit board is mounted as shown in Figure 2-6, with the heat sink toward the rear of the chassis. On the upper side of the chassis, remove or scrape off paint within 1/8 inch of the hole at location **D.** This insures that the solder lug mounted above the circuit board makes a good electrical connection to the chassis. Insert one screw from below the chassis through the hole shown at **A.** Place a spacer over the screw, and then the circuit board. Make sure that the board is positioned so that the heat sink is on top of the board. Place a lockwasher and a nut on the screw and give the nut a few turns. Do not tighten the screw. In the same way, loosely mount the board at **B** and **C.** Mount the board at **D**, where the solder lug is used instead of a lockwasher. The solder lug points toward the rear of the chassis. Tighten the four screws.

(✓) **Step 14**

PARTS NEEDED

3—Modular Connectors

Mount three modular connectors at positions 1, 2 and 6 on the design panels, as shown in Figure 2-6. There are now six modular connectors mounted on the design panels.

(✓) **Step 15**

PARTS NEEDED

1—Partially Assembled
Design Console

—Solder

The following wiring and soldering connects the remaining terminals of the switch, the potentiometer and the transformer to the circuit board. Note that the leads from circuit board terminals 2, 11 and 12 will go to three modular connectors added to the top of the design console. The leads to the switch and potentiometer go through the rubber grommets already installed, and "double back" like the wiring done in Project 1. Figure 2-6 shows how the wiring is routed so that terminals and other test points will be easy to reach for testing, circuit analysis and possible troubleshooting.

For this wiring, use the following table. **CB** is the circuit board, **MC** is a modular connector, **POT** is the potentiometer, **SW** is the switch and **TRF** is the transformer. One lead is not soldered (NS) at potentiometer terminal No. 1. The terminals to be soldered are indicated as (S). This is shown below. You may want to check off each of these wires as it is connected.

From Terminal	*To Terminal*	*Wire Color*	*See Figure No.*
CB 1	TRF 8 (S)	White	1-7 X
CB 2	MC 6	Red	2-6 X
CB 3	SW 5 (S)	Red	2-5 X
CB 4	POT 1 (NS)	Black	2-5 X
CB 5	TRF 4 (S)	Yellow	1-7 X
CB 6	SW 7 (S)	White	2-5 X
CB 7	POT 3 (S)	Blue	2-5 X
CB 9	TRF 1 (S)	Black	1-7 X
CB 10	POT 2 (S)	Yellow	2-5 X
CB 11	MC 1	Black	2-6 X
CB 12	MC 2	Yellow	2-6 X

☒ **Step 16**

PARTS NEEDED

1—Partially Assembled Design Console

—Solder

Wire (as shown below)

This step will complete the wiring and soldering of the design console, Stage 2.

Cut three wires as indicated below. Strip off the ¼″ of insulation from both ends of each wire. Soldering is indicated by (S). Again, you should check off each wire as you install and solder it.

Color	*Length, Inches*	*From Terminal*	*To Terminal*
Black	2	POT 1 (S)	SW 8 (S)
Yellow	28	TRF 9 (S)	SW 3 (S)
Blue	28	TRF 3 (S)	SW 4 (S)

(✓) **Step 17**

Inspect all wiring and soldering at the transformer terminals. Be sure that all excess bare wire has been clipped off and that no excess solder appears at the terminals or on the transformer windings.

Excess solder at a terminal can be removed by reheating it with your soldering iron while the design console is positioned so that the molten solder will flow toward the outer end of the terminal.

Inspect all wiring and soldering at the switch and potentiometer terminals. Again, be sure that no excess bare wire or solder is present.

(____) **Step 18**

PARTS NEEDED

—Multimeter and Test Leads

2—Test Prod Spring Adapters

Collect all unused wire and put it away. Some of it will be used in the experiments that follow. Arrange the wiring for a neat appearance. (This is called "dressing the wires.")

A temporary label may be used to show the switch and potentiometer functions. Cut out the label shown in Figure 2-7. Attach it to the chassis with transparent tape, rubber cement or household glue.

Rotate the switch to its center position. The knob pointer should align with the 6V mark on the label. If it does not, remove the knob, loosen the switch mounting nut and readjust the switch position. Tighten the nut and replace the knob. Turn both knobs fully counterclockwise (to the left) and plug in the line cord.

With your long-nose pliers, put a slight bend in the center of each of your spring adapters. Refer to Figure 2-8A. Thread a spring adapter on each test lead as shown in Figure 2-8B. These spring adapters can then be left on the meter test leads. Plug the negative (black) multimeter test lead into Modular Connector No. 1, and the positive (red) lead into Modular Connector No. 2. Set the meter range to the position which will best indicate about 8V dc.

Turn the design console switch one click clockwise, or to the **6V** position.

You should read about 1V dc. Slowly turn the potentiometer knob clockwise. The voltage should increase smoothly to about 7V dc. Return the knob to full counterclockwise.

Set the meter range to read about 35V dc. Turn the switch another click to full clockwise, or to the **30V** position. You should read about 1V dc. As the potentiometer knob is turned clockwise, the voltage should increase smoothly to about 32V dc.

As you have just observed, this power supply voltage is adjustable. This voltage is also regulated (maintained constant) for any current load within these power supply ratings:

6V position 1V dc to 4V dc at up to 300 mA.

4.1V dc to over 6V dc at up to 400 mA.

30V position 6V dc to 15V dc at up to 100 mA.

15.1V dc to 25V dc at up to 150 mA.

25.1V dc to 30V dc at up to 200 mA.

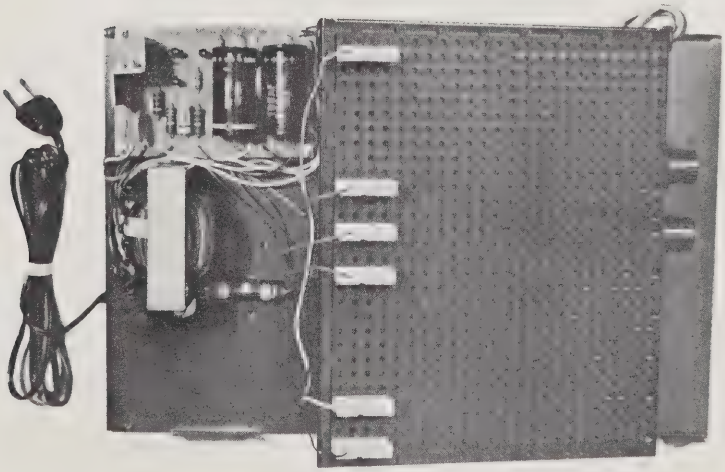


Figure 2-1

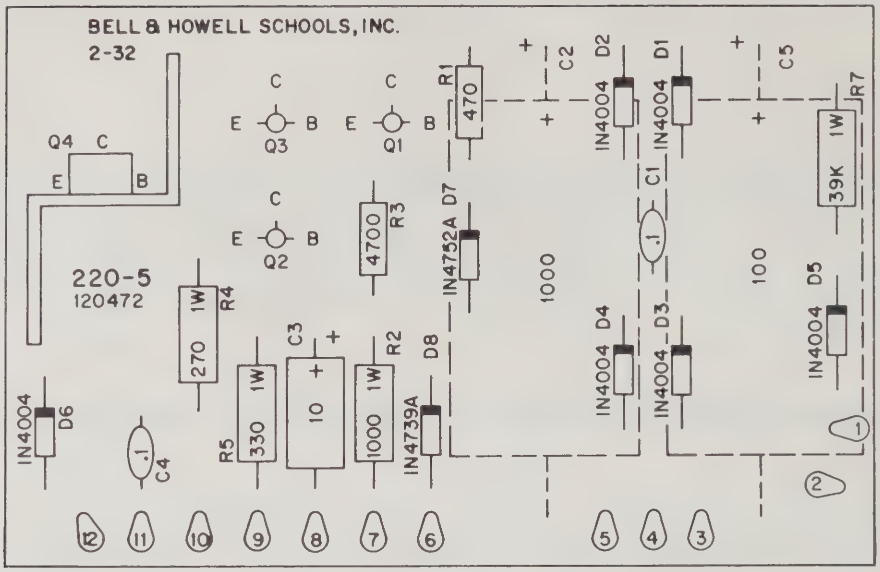


Figure 2-2

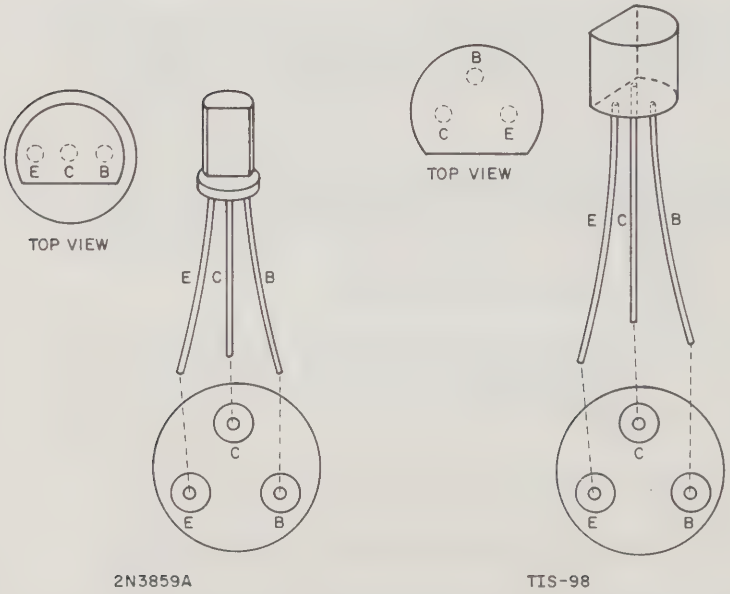


Figure 2-3

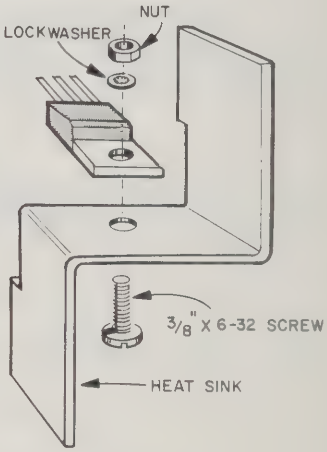


Figure 2-4

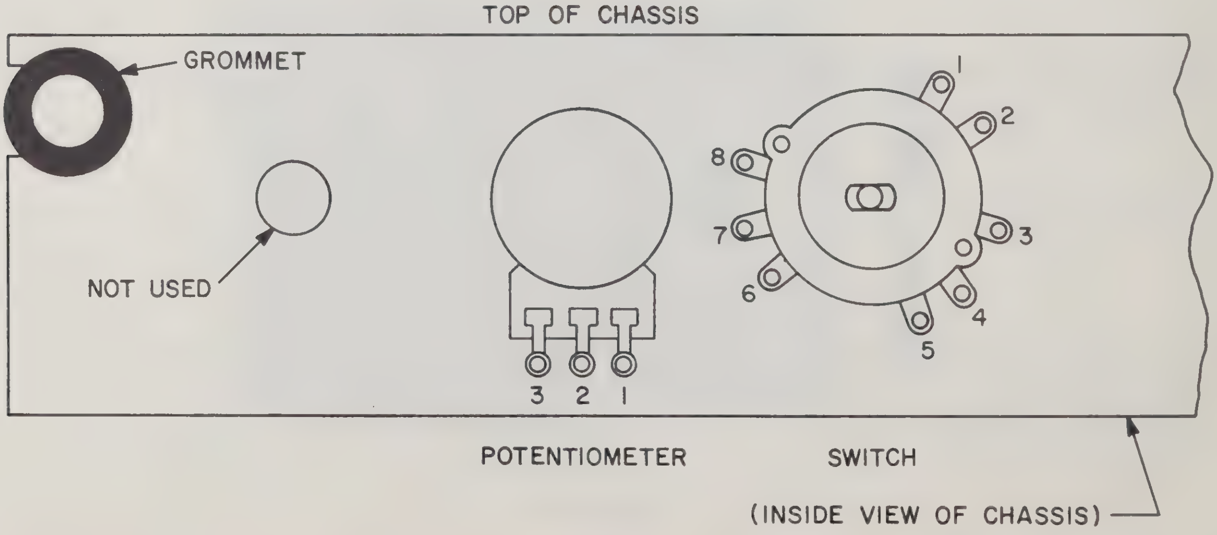


Figure 2-5

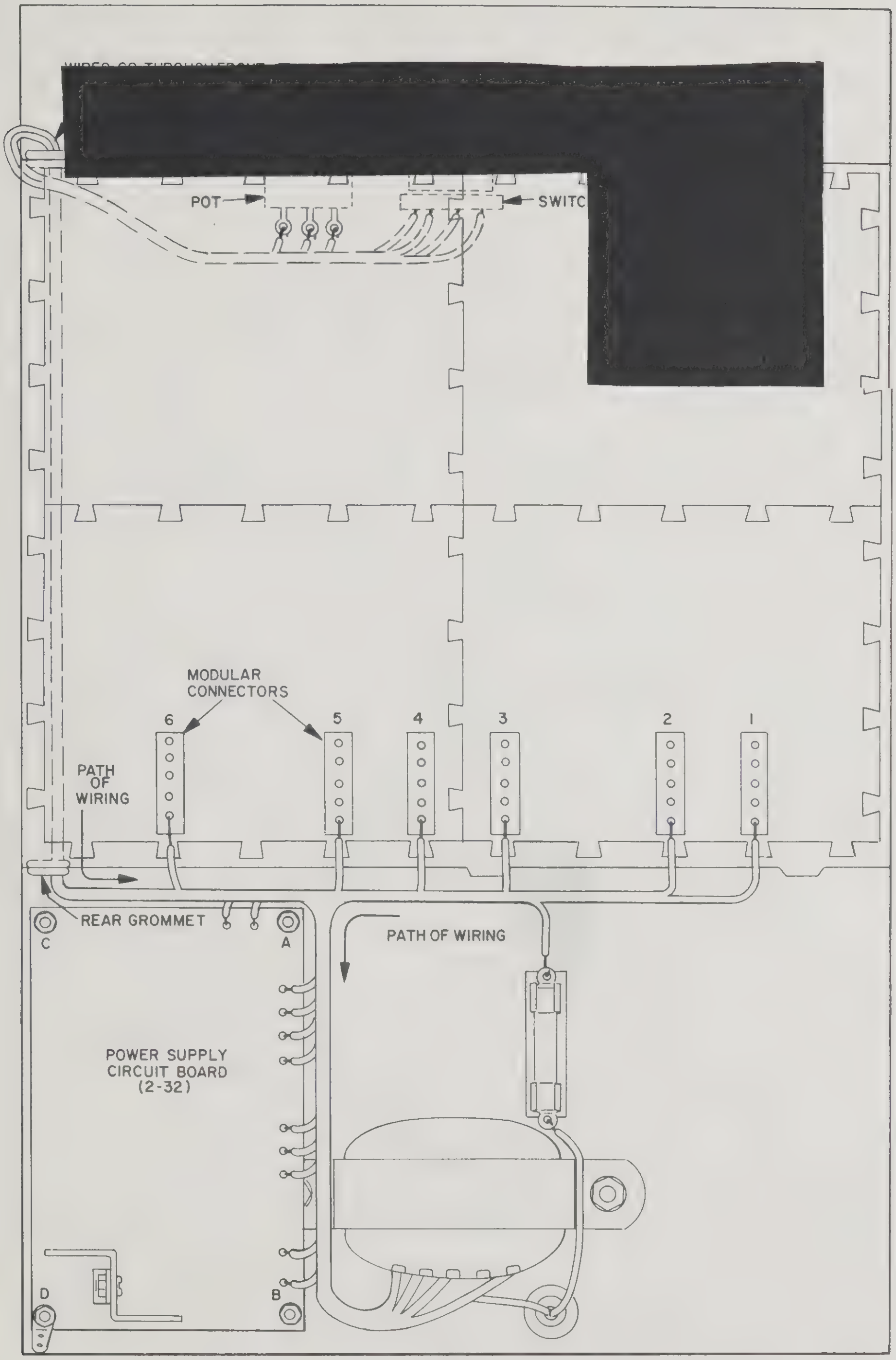

[redacted]
POT
SWITC
MODULAR CONNECTORS
6
5
4
3
2
1
PATH OF WIRING
REAR GROMMET
C
A
PATH OF WIRING
POWER SUPPLY CIRCUIT BOARD (2-32)
D
B

Figure 2-6

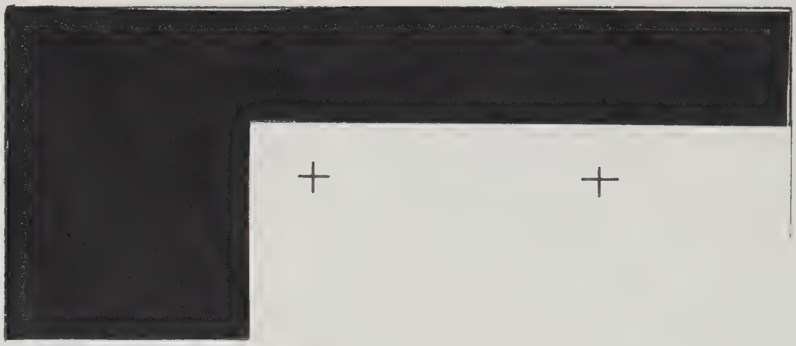


Figure 2-7

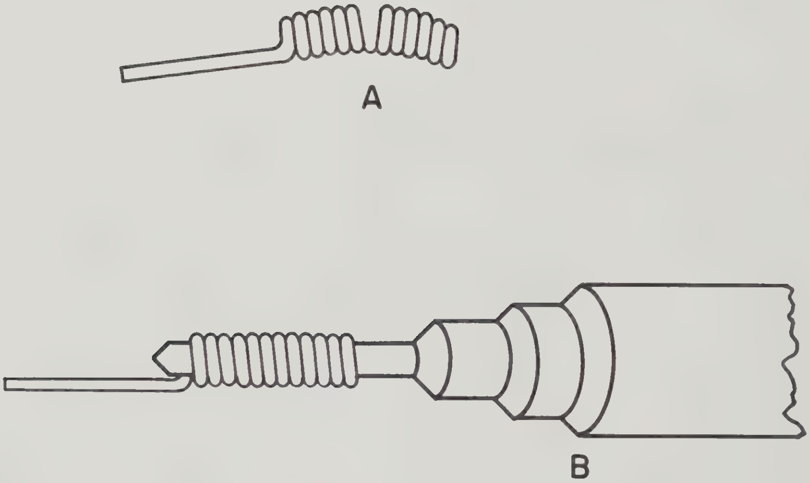


Figure 2-8

MATERIALS FOR PROJECT 3

1—Design Console—Stage 2
1—Speaker
1—Impedance-Matching Transformer
1—Circuit Board (Part No. 2-31)
3—390Ω, ½ W, 10% Resistors
4—2200Ω, ½ W, 10% Resistors
1—2200Ω, 1 W, 10% Resistor
2—4700Ω, ½ W, 10% Resistors
1—68 kΩ, ½ W, 10% Resistor
1—220 kΩ, ½ W, 10% Resistor
1—470 kΩ, ½ W, 10% Resistor
1—10 kΩ, 10 kΩ, Dual Potentiometer
1—.0022 Disk Capacitor
3—.022 μF Capacitors
2—.1 μF Disk Capacitors
2—100 μF Electrolytic Capacitors
4—2N3393 Transistors
1—1N4004 Diode
1—Black Knob
1—Neon Lamp
1—Red Lens
1—Terminal Collar
1—5/16″ Push-on Nut
12—Aluminum Binding Posts
12—Black Binding Post Caps
4—Black Base Insulators
4—Red Base Insulators
4—Yellow Base Insulators
6—Green Base Insulators
6—Blue Base Insulators
1—Front Panel
1—Rear Panel
1—Left Side Panel
1—Right Side Panel
6—6-32 × ⅜″ Screws
4—6-32 × ⅞″ Screws
4—½″ Spacers
10—No. 6 Lockwashers
34—6-32 Nuts
12—No. 6 Solder Lugs
14—8-32 Hex-head Screws
1—⅜″ Lockwasher
1—⅜″ Flat Washer
1—⅜″ Nut
2′ of 2-Wire Shielded Cable
5′ of Yellow Wire
5′ of Blue Wire
10′ of Gray Wire
5′ of Black Wire
5′ of White Wire
5′ of Brown Wire
6′ of Solder

PROJECT 3

COMPLETION OF DESIGN CONSOLE

DISCUSSION

This construction project will complete your Electro-Lab® Design Console. It will appear as shown in the frontispiece photograph.

In this final project you will assemble a printed-circuit signal generator. You will then install the generator, a speaker and impedance-matching transformer, the front panel and controls, and the rear panel and binding post assembly into the design console. Final internal wiring and mechanical assembly will then complete your design console.

PROCEDURE

Refer to Figure 3-1 for the location of all components on circuit board Part No. 2-31.

(✓) **Step 1**

PARTS NEEDED

1—Circuit Board (Part No. 2-31)

1—1N4004 Diode

2—390Ω Resistors

—Solder

Insert the 1N4004 diode at $\mathbf{D}_1$. Be sure that the polarity is correct, as shown in Figure 3-1, and that the marking is visible. Insert one 390Ω resistor at $\mathbf{R}_1$ and the other at $\mathbf{R}_2$. The parts should be installed tightly against the circuit board. Solder these six connections, inspect them, and clip off the excess projecting leads, one at a time.

(✓) **Step 2**

PARTS NEEDED

1—390Ω Resistor

2—4700Ω Resistors

—Solder

Insert the 390Ω resistor at $\mathbf{R}_{11}$, one 4700Ω resistor at $\mathbf{R}_7$, and the other 4700Ω resistor at $\mathbf{R}_5$. Solder these six connections. Inspect them and clip off the excess projecting leads one at a time, as in Step 1.

(✓) **Step 3**

PARTS NEEDED

5—2200Ω Resistors

—Solder

Note that one 2200Ω resistor (the 1-watt size resistor) is larger than the others. Insert it at $\mathbf{R}_{12}$. Insert a ½ watt, 2200Ω resistor at $\mathbf{R}_8$. Solder these four connections, inspect them, and clip off the excess projecting leads. Insert the remaining three ½ watt, 2200Ω resistors at $\mathbf{R}_9$, $\mathbf{R}_4$ and $\mathbf{R}_6$. Solder these six connections, inspect them, and clip off the excess projecting leads.

(✓) **Step 4**

PARTS NEEDED

1—220 kΩ Resistor

1—470 kΩ Resistor

2—.1 μF Disk Capacitors

—Solder

Insert the 220 kΩ resistor at $\mathbf{R}_{10}$ and the 470 kΩ resistor at $\mathbf{R}_3$. Insert one 0.1 μF capacitor at $\mathbf{C}_6$ and the other at $\mathbf{C}_5$. Solder these eight connections, inspect them, and clip off the excess projecting leads.

(✓) **Step 5**

PARTS NEEDED

1—.0022 μF Disk Capacitor

3—.022 μF Capacitors

—Solder

NOTE: The .0022 μF disk capacitor may be marked "2200 pF" (which is the same value). Insert that capacitor at $\mathbf{C}_4$. Insert the three .022 μF capacitors at $\mathbf{C}_1$, $\mathbf{C}_2$ and $\mathbf{C}_3$. Solder these eight connections, inspect them, and clip off the excess projecting leads.

(✓) **Step 6**

PARTS NEEDED

4—2N3393 Transistors

—Solder

Insert one of these at $\mathbf{Q}_1$ with its flat side facing the numbers along the bottom edge of the circuit board. See Figures 3-1 and 3-2. Press its leads through the board until the base of the transistor is ¼″ above the board. Slightly spread the leads below the board to hold it in position, and solder these three connections. Inspect them and clip off the excess projecting leads. In the same manner, insert another 2N3393 transistor at **Q_2**, solder these three connections, inspect them, and clip off the excess projecting leads. Install the remaining two transistors at **Q_3** and **Q_4**. Solder and check these connections. Clip off the excess projecting leads.

(____) **Step 7**

PARTS NEEDED

2—100 μF Electrolytic Capacitors —Solder

Insert these capacitors at **C_7** and **C_8**. Be sure that the polarity is correct as shown in Figure 3-1, and that the values are visible. Solder these four connections, inspect them, and clip off the excess projecting leads.

(____) **Step 8**

Wire (as shown below) —Solder

Connecting wires must be soldered to the circuit board input and output terminals before the board can be mounted to the chassis. Cut each wire to the length shown in the table below, and strip ¼″ of insulation from both ends of each wire. Insert one end of each wire (in the order given below) through the board FROM the component side. Solder each wire to the board, one at a time. Inspect that connection, and clip off any excess projecting wire. You may wish to check off the wires from the list below as you solder and inspect them.

Color	*Length, Inches*	*To Circuit Board Terminal Number*
Blue	14	3 (S)
Gray	14	4 (S)
Black	12	6 (S)
Yellow	10	7 (S)

(____) **Step 9**

PARTS NEEDED

2-Wire Shielded Cable —Solder

Carefully remove one inch of the outer plastic covering from each end of the cable. At one end, open the foil shielding by hand and cut it off flush with the plastic covering. You will see three flexible wires, one black, one with transparent plastic insulation, and one without insulation. Carefully remove ¼″ of insulation from both insulated wires. In the same manner, prepare the other end of the cable for soldering. Twist the exposed wires to gather up any loose strands. Insert the wire with the transparent insulation FROM the component side of the board into Terminal Number 1, solder and inspect that connection and clip off the excess wire. Next, insert the black wire into Terminal Number 2, and connect as before. Insert the noninsulated wire into Terminal Number 5 for about ¼″, solder, inspect the connection and clip off any excess projecting wire.

(X) **Step 10**

PARTS NEEDED

1—Design Console—Stage 2

1—Assembled Circuit Board

4—6-32 × ⅞″ Screws

4—½″ Spacers

4—No. 6 Lockwashers

4—6-32 Nuts

Mount the circuit board in the position shown in Figure 3-3, with the attached wires toward the front of the chassis. Insert one screw from below the chassis at position A. Place a spacer over it and then the corresponding mounting hole in the circuit board. Place a lockwasher and nut on the screw. Do not tighten the screw. In the same manner, mount the board at corners B, C and D. Then tighten all four mounting screws.

Remove the green wires from the three modular connectors. Carefully straighten each wire while bringing it around to the terminal side of the transformer. These wires will later be connected to three binding posts on the rear panel. Remove the three modular connectors to which the green wires were connected and place the modular connectors with your experimental parts.

(X) **Step 11**

PARTS NEEDED

1—Speaker

4—6-32 × ⅜″ Screws

4—No. 6 Lockwashers

4—6-32 Nuts

Mount the speaker as shown in Figure 3-3 with its terminals toward the power transformer. Insert the four screws from inside the chassis cavity, place the speaker over them, and complete the mounting using the four lockwashers and nuts. The speaker frame may not fit flat against the chassis surface. In that case, do not over tighten the screws and bend the speaker frame.

(✓) Step 12

PARTS NEEDED

1—Impedance-Matching Transformer
2—No. 6 Lockwashers
2—6-32 × 3/8″ Screws
2—6-32 Nuts

Mount this transformer with its terminals toward the power transformer, as shown in Figure 3-3. Insert the two screws from below the chassis and place the transformer over the screws. Complete the mounting, using the two lockwashers and nuts. You may loosen the mounting screws of the power supply circuit board to make this transformer mounting easier. Be careful not to disturb the heat sink on the power supply board. After installing the transformer, make sure that all mounting screws are reasonably tight.

(✓) Step 13

PARTS NEEDED

—Solder

Free the shielded cable from the other four attached wires, and route it along the edge of the chassis, below the speaker, toward the rear grommet. Near the grommet it will be joined by the wires from the power supply. Feed the shielded cable through both grommets to the front of the chassis. It will be connected later.

Run the yellow wire from board Terminal Number 7 toward the fuse, over the shielded cable, around the mounting spacer at corner A, and toward the line cord bushing. Solder this yellow wire to power transformer Terminal Number 9, which already has a wire soldered to it.

In the same manner, run the black wire from board Terminal Number 6 to power transformer Terminal Number 1 and solder. Route the gray wire from board Terminal Number 4 and the blue wire from board Terminal Number 3 out beyond the line cord bushing. These two wires will be connected to two binding post terminals on the rear panel assembly.

(____) Step 14

PARTS NEEDED

Yellow Wire
—Solder
Gray Wire

Bend a hook in each of the flexible leads from the smaller transformer. Connect the lead nearer the speaker to its upper terminal. Pass the stripped end through the terminal,

IMPORTANT NOTICE

To reduce the possibility of damaging the regulated low-voltage supply during the course of the laboratory work, a fuse will be added to the power supply.

Parts List

✓ 1 - Fuse Block
✓ 1 - Fuse (0.25 Amperes)
✓ 1 - No. 6, Sheet-Metal Screw
✓ 1 - 6-32 x 3/16 Black-Machine Screw

When you have completed Project 2 of the Design Console construction, ending on Page 2-11 in Manual 9501, mount a fuse block with a 6-32 x 3/16" Black-Machine Screw to the Modular-Design panel in the approximate location shown in Figure 1. Remove the yellow wire connected to MC 2 and solder it to one end of the Fuse Block. From your supply or wire, select a 2" piece (any color) and solder one end of wire to the other Fuse Block terminal. Connect the other end of this wire to MC 2 as shown. Insert a 0.25 ampere fuse into the block. This fuse is in series with the output of the regulated power supply and will open if a short occurs thus protecting the supply. The fuse will be permanently mounted at the completion of Project 3.

While you are performing the final construction of the Design Console in Project 3 of Manual 9501, unsolder the yellow wire connected to the fuse block that comes from Hole 12 on the power supply board.

Using a 6-32 sheet-metal screw, mount the Fuse Block to the slot in the aluminum extrusion in the position shown in Figure 2. The sheet-metal screw will thread into the slot extrusion. Do not over tighten the screw or you may damage the Fuse Block or the extrusion.

After completing Project 3 in Manual 9501, refer to Figure 2. Remove the wire from binding post 4 (yellow to hole 12 on Power Supply Circuit Board) and connect it to one lug on the Fuse Block. From your supply of wire select a 6" piece of yellow wire and connect it from the other Fuse Block lug to binding Post 4.

Always replace the fuse with a 0.25 Ampere 3AG type fuse. Do not use a slow-blow fuse or a fuse with a higher current rating. If this is done the power supply will not be protected from short circuit damage.

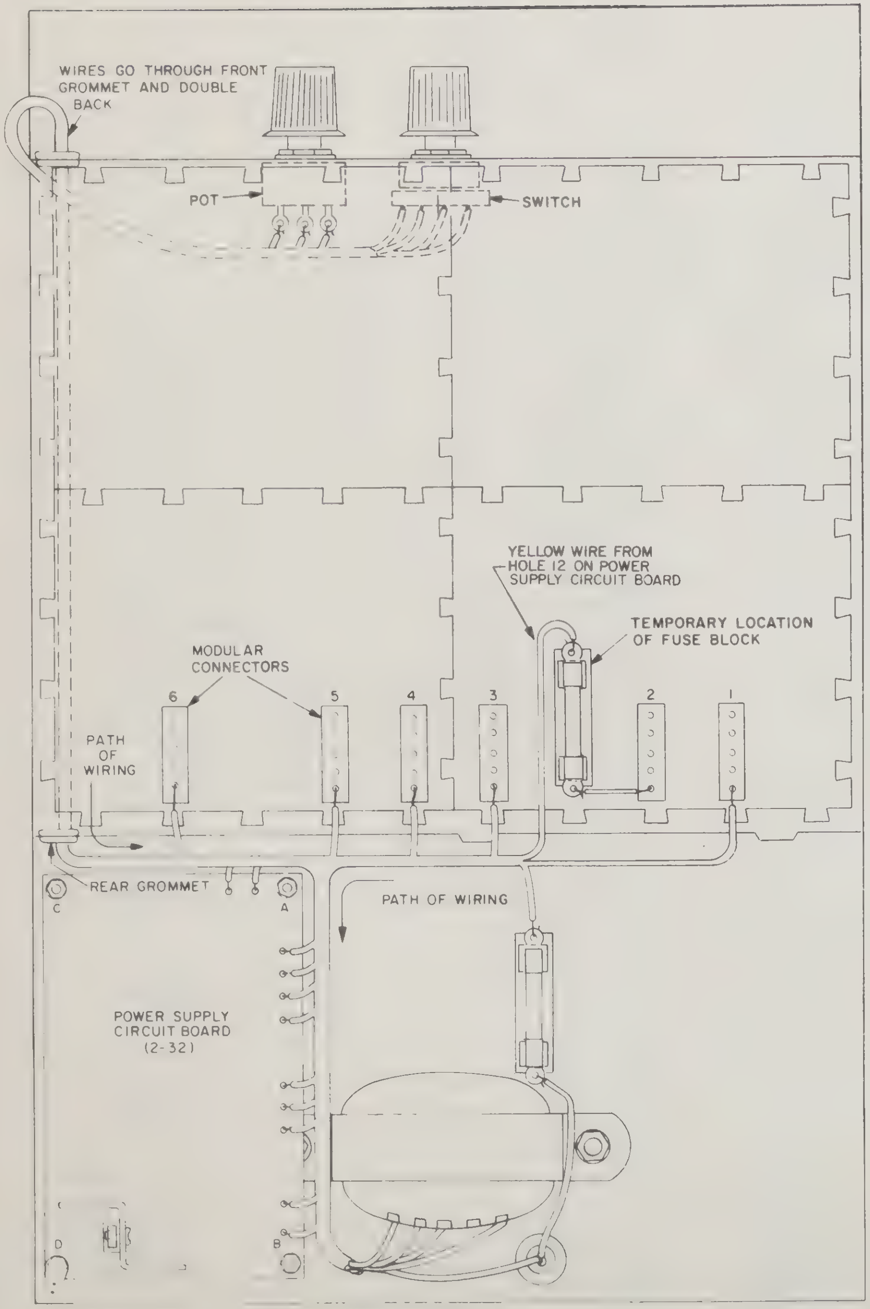

WIRES GO THROUGH FRONT GROMMET AND DOUBLE BACK
POT
SWITCH
YELLOW WIRE FROM HOLE 12 ON POWER SUPPLY CIRCUIT BOARD
TEMPORARY LOCATION OF FUSE BLOCK
MODULAR CONNECTORS
6
5
4
3
2
1
PATH OF WIRING
REAR GROMMET
C
A
PATH OF WIRING
POWER SUPPLY CIRCUIT BOARD (2-32)
D
B

FIGURE 1

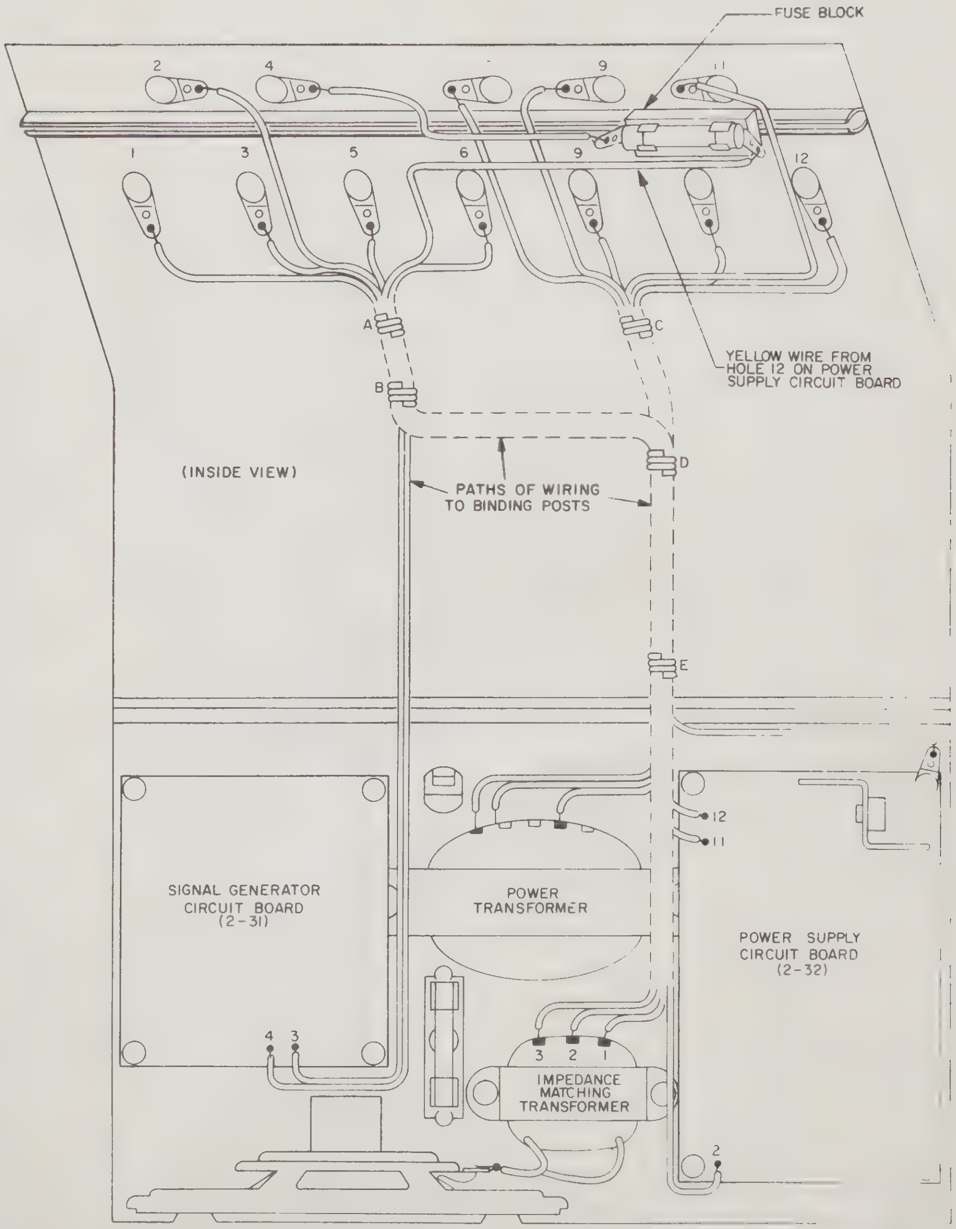

FUSE BLOCK
2
4
9
11
1
3
5
6
9
12
A
C
YELLOW WIRE FROM HOLE 12 ON POWER SUPPLY CIRCUIT BOARD
B
D
(INSIDE VIEW)
PATHS OF WIRING TO BINDING POSTS
E
12
11
SIGNAL GENERATOR CIRCUIT BOARD (2-31)
POWER TRANSFORMER
POWER SUPPLY CIRCUIT BOARD (2-32)
4
3
3
2
1
IMPEDANCE MATCHING TRANSFORMER
2

FIGURE 2

crimp lightly, solder, and clip off any excess wire. Use only the amount of solder necessary, and be careful not to damage the speaker cone. Connect the other lead to the lower speaker terminal. Solder and clip off any excess wire.

Cut one 12″ length of yellow wire, one 13″ length of gray wire, and one 14″ length of gray wire. Strip ¼″ of insulation from both ends of each wire.

Bend a small hook at one end of the yellow wire and put it through Terminal Number 1 of the smaller transformer. Crimp lightly, solder and clip off any excess wire. Remember, use only the amount of solder required to make the connection. Run this lead along the edge of the power supply circuit board, and out beyond the rear edge of the chassis.

Connect the 13″ gray wire to Terminal Number 2 of this transformer and the 14″ gray wire to Terminal Number 3. Solder, and bring these two wires out to the rear in the same manner. These three wires will be connected later to binding post terminals on the rear panel assembly.

(X) **Step 15**

PARTS NEEDED

1—Left Side Panel

1—Right Side Panel

6—8-32 Hex-head Screws

Remove the black knobs from the switch and potentiometer shafts. Remove the switch and the potentiometer, and replace the lockwasher, the flat washer and the nut on each of their bushings. Bring them around to the front of the chassis and straighten the attached wires, which now come straight out from the front grommet. Remove the paper label from the chassis.

Figure 3-4 shows the left side panel. Put a screw through its top center hole of the left side panel from the finished side, and align the screw with the hole in the short mounting tab at the top center on the left hand side of the chassis. Use a nut-driver, if possible, and carefully start the screw straight into the hole. Turn the screw about half way through the hole.

Start another screw into the short mounting tab at the left front side of the chassis. If the hole does not line up with the screw, bend the chassis to restore it to its original shape. In the same manner, start a screw into the short mounting tab at the left rear side of the chassis. Tighten these three screws to fasten the left side panel to the chassis. Avoid overtightening, which could strip the threads in the tabs.

Check to see that the grommets are in place and that the wires are dressed away from the panel and the chassis edge. Mount the right side panel to the chassis in the same manner. Watch that the screws do not damage the insulation on the wires as the panel is fastened to the chassis.

(X) **Step 16**

PARTS NEEDED

1—Front Panel (for Controls)

1—Dual Potentiometer

1—⅜″ Lockwasher

1—⅜″ Flat Washer

1—⅜″ Nut

1—Neon Lamp

1—Red Lens

1—5/16″ Push-on Nut

1—Terminal Collar

1—68 kΩ Resistor

The dual potentiometer may have a "locating tab" that would prevent it from being mounted flush against the panel. If so, bend the tab outward.

Place the ⅜″ lockwasher on its bushing and insert it from behind the front panel into the hole marked ADJUST FREQ. Place the flat washer and the nut on the bushing and position the potentiometer terminals toward the top of the panel, as shown in Figure 3-5. "Finger tighten" the nut and temporarily mount a knob on its shaft with the setscrew tightened against the flat side of the shaft.

Rotate the knob fully counterclockwise. If the arrow on the knob does not line up with the 0 line on the panel, rotate the body of the potentiometer so that it does line up. Remove the knob. Tighten the nut carefully to avoid scratching the panel.

From the front side of the panel, insert the red plastic lens through the hole marked POWER ON. Behind the panel, fit the hollow side of the push-on nut over the lens body with the hollow (concave) side of the nut toward the panel and push the nut toward the panel until the lens is securely fastened. You may have to push the nut with a screwdriver while the lens is resting on a flat surface. Again, be careful not to scratch the panel. Insert the neon lamp completely into the lens body with its lead projecting straight out the rear of the lens body. Slip the terminal collar over the lens body and push it (don't push on the lugs) against the nut with the terminals positioned as shown in Figure 3-5. Pass the neon lamp leads through Terminals 1 and 2, wrapping them around the terminals to hold the lamp in position. Pass the leads of the 68kΩ resistor through Terminals 1 and 3, bend them around the terminals and clip off the excess wire. The terminals will be soldered later.

(X) **Step 17**

PARTS NEEDED

1—Partly Completed Design Console

2—8-32 Hex-head Screws

1—Partly Assembled Front Panel

Inside the front panel you will find two C-shaped channels. Line up the lower channel with the lower left and right front holes in the side plates and start a screw into each side. The screws will pass through the side panels and cut a thread in the channel. If possible, use a nut-driver. Run the screws in almost all the way, but do not tighten them.

Remove the nuts and flat washers from the switch and the potentiometer, already wired, but leave the lockwashers on their bushings. Insert the potentiometer from behind the panel through the hole marked ADJUST VOLTAGE. Insert the switch through the remaining hole marked OFF-6V-30V. Place the flat washers and the nuts on their bushings, position the switch and potentiometer from behind the panel as shown in Figure 3-5 and tighten the nuts "finger tight." Temporarily mount the knobs on the shafts and then check the knob arrow alignments with the panel markings. If necessay, rotate the controls from inside the panel until the alignment is proper. Then, remove the knobs and carefully tighten the control nuts. Do not scratch the panel.

(X) **Step 18**

PARTS NEEDED

1—Partly Completed Design Console

—35″ of Brown Wire

3—Black Knobs

—Solder

2—8-32 Hex-head Screws

Strip 2″ of insulation off one end of the wire, and clip it off to provide 2″ of bare wire. Form the bare wire into a U-shaped loop that will fit through the dual potentiometer Terminals 2 and 5, as shown in Figure 3-6. Pass the two ends down through Terminals 2 and 5, and up through Terminals 3 and 6. Bend them around Terminals 3 and 6 as shown, and clip off the excess wire. Connect the wires from the shielded to the dual potentiometer terminals, as shown in Figure 3-6. Solder and inspect all six connections.

Cut the remaining wire into a 5″ length and a 28″ length. Strip the insulation for ¼″ at both ends of each wire. Connect the 5″ brown wire to the lamp assembly Terminal 3. Solder it and the lead of the 68 kΩ resistor at Terminal 3. Solder the other resistor lead and the neon lamp lead at Terminal 1.

From Terminal 3, run the brown 5″ wire to switch Terminal 1, which already has a brown wire soldered to it, and solder it there. Connect one end of the 28″ brown wire to lamp assembly Terminal 2. Solder this wire and the other neon lamp lead at Terminal 2.

Run the free end of the long brown wire to the front grommet, leaving some "slack" in the wire, pass it through the grommet, and through the rear grommet. (Tip the design console on its right side to feed the wire through the rear grommet.) Following the path of the wire already installed, connect and solder this wire to Terminal 7 of the power transformer. Make sure that the hot soldering iron doesn't touch any of the nearby wires.

Inspect all front panel connections. Check that the neon lamp wires are well separated. Carefully route all wires down to the bottom of the panel, and close the front compartment by raising the panel. Route the bare wire in the shielded cable so that it doesn't touch any of the other potentiometer terminals. Put the two screws through the side panel holes near the top of the panel and carefully tighten them. If they do not align with the C-shaped channel at the top of the panel, the panel can be slightly bent along the thin section where the panel curves to obtain a perfect fit. Tighten all four screws.

Notice that this front compartment may be opened easily by removing the two top screws and loosening the two bottom screws.

Mount the three black knobs on the shafts with their setscrews tightened against the flat surfaces. The knobs should be sufficiently above the panel surface that they do not rub on the panel surface.

(✓) **Step 19**

PARTS NEEDED

1—Rear Panel (for Binding Posts)
12—Aluminum Binding Posts
12—Black Binding Post Caps
4—Black Base Insulators
4—Red Base Insulators
4—Yellow Base Insulators
6—Green Base Insulators
6—Blue Base Insulators
12—No. 6 Solder Lugs
24—6-32 Nuts

Put your partly completed design console aside. Provide a surface to work on (newspaper, cardboard, etc.), so that the panel or your table will not be scratched. Take one aluminum binding post and two black base insulators. Notice that the binding post has a flat side on the base that fits into a matching cavity in the insulator, and that two base insulators will interlock when they are put together with their locking pins engaged. Figure 3-7 shows the numbered location and the base insulator color-coding for the 12 binding posts to be mounted on the rear panel. The base insulators are used in pairs of matching color, one above and one below the chassis. With a lead pencil, number the binding post locations on the inside surface of the rear panel as shown in the inside view of Figure 3-7 and also in Figure 3-8.

The first (black) binding post is assembled as follows. From the outside (labeled side) of the panel, insert a black base insulator into rear panel hole Number 1 so that the flat part of the cavity is toward the rear, facing the label "EXT. GND." Insert a binding post into the insulator hole. Place another black base insulator over the screw projecting from inside the rear panel with its locking pins toward the panel. The position of the flat side of its cavity is not important. Place a 6-32 nut on the screw and tighten it with your nut driver. Mount the other eleven binding posts in the same manner, matching colors of the base insulators as indicated in Figure 3-7.

Put a solder lug, bending outward (away) from the back panel, and a nut on each projecting screw. Before tightening the second nut on each binding post, align its solder lug as shown in Figure 3-7. Screw the twelve black binding post caps onto the twelve binding posts.

(X____) **Step 20**

PARTS NEEDED

1—Partly Completed Design Console

1—Rear Panel and Binding Post Assembly

4—8-32 Hex-head Screws

—White Wire

—Solder

Align the C-shaped channel at the bottom of the rear panel with the two bottom rear holes in the side panels of the design console. Insert the two hex-head screws, one from each side, and carefully turn them in until they are almost tight.

When making each of the following connections, form the stripped end of the wire into a U-shaped hook by bending it with your pliers ⅛″ from the end. Put the hook through the specified terminal, crimp lightly, solder and inspect the soldered connection.

Cut a white wire 15″ long and strip off ¼″ of insulation at both ends of the wire. Connect the white wire to the solder lug at the rear of the power supply circuit board.

You may wish to check off each wire in the following list as you finish soldering it.

2-31 is the signal generator circuit board.

2-32 is the power supply circuit board.

MTRF is the impedance-matching (smaller) transformer.

PTRF is the power (larger) transformer.

Wire Color	*From Part*	*Terminal Number*	*To Binding Post Number*
Blue	2-31	3	5
Gray	2-31	4	6
Red	2-32	2	3
White	(Solder lug on 2-32)		1
Yellow	MTRF	1	8
Gray	MTRF	2	10
Gray	MTRF	3	12
Yellow	2-32	12	4
Black	2-32	11	2
Green	PTRF	2	7
Green	PTRF	10	9
Green	PTRF	5	11

The wiring to the binding posts follows the inside surface of the rear panel. Group the wires as shown in Figure 3-8. This arrangement allows for easy access to any component at the rear of the design console when the rear panel is swung open. It also keeps this wiring well separated from all components when the rear panel is closed. To keep it in place, wrap it as shown at A, B, C, D and E, each with about 2½″ of insulated wire. Close the rear panel, slightly spreading the side panels, if necessary, to avoid scratching their painted surfaces. Insert the remaining screws and carefully tighten them. Avoid stripping the cut threads by tightening the screws only until they are firmly against the panel sides. Tighten the two screws at the bottom end of the rear panel.

(____) Step 21

PARTS NEEDED

Completed Design Console

Multimeter with Test Leads and Test Prod Spring Adapters

This testing procedure will provide an overall check of your design console performance. **MAKE SURE THE DESIGN CONSOLE AC LINE CORD IS DISCONNECTED FROM THE AC OUTLET WHILE MAKING RESISTANCE MEASUREMENTS**. There may be small differences between your measured and the specified readings. If you find a large difference, check your meter range first, and then check the internal wiring of the design console.

Make the RESISTANCES below. Figure 3-7 shows the numbering of the binding posts.

From Binding Post Number	*To Binding Post Number*	*Resistance*
1	All others	Infinite Ω (∞)
1	Setscrew on switch knob	0Ω
2	3	Above 300Ω
2	4	Above 500Ω
2	All others	Infinite Ω (∞)
7	9	*0.6Ω
7	11	*1.2Ω
8	10	15.7Ω
8	12	181Ω

*Because of their small values, these resistances will appear almost as 0 ohms on your multimeter. Be sure that the meter is properly zeroed.

Turn the switch to 6V, but do NOT plug in the design console line cord. Between the prongs of the line cord plug, you should read about **17**Ω. From either prong to binding post Number 1, you should read ∞Ω.

Turn the switch to OFF and the other two knobs maximum counterclockwise. Plug in the line cord. Turn the switch to 6V. The POWER ON indicator should light up. Check these output voltages. Again, small differences between your readings and the specified readings may be caused by the normal tolerances of the circuit and the accuracy of your multimeter. Large differences should be investigated. These voltage readings, except for the REG. DC outputs, will also depend on the line voltage at your ac line outlet receptacle. They are given below for a line voltage input of 115V ac, and will be slightly higher than the panel markings because no load is present except for the very small current delivered to the multimeter. Measure the REG. DC output. The output voltage, controlled by the ADJUST VOLTAGE knob, should be adjustable from about 1.2V dc to about 7.6V dc. Set the switch to **30V.** The output voltage should be adjustable from about 1.3V dc to about 33V dc. Measure **+180V** at binding post Numbers 2 and 3. You should read about 190V dc. Across the **12.6V** ac output, you should read about 14V ac. From either **6.3V** binding post to the **0** binding post between them, you should read about 7V ac. Measure the SIG. GEN. outputs between binding post Numbers 2 and 5, and 2 and 6. The outputs will change slightly as the ADJUST FREQ. knob is turned, but should be from 4 to 8V ac. To test the speaker and its impedance-matching transformer, connect a wire from REG. DC (—) to SPEAKER (COM.). Connect another wire to SIG. GEN. (∿), which is the sinewave output. Touch the other end of this wire to SPEAKER (400Ω) and then to SPEAKER (4 kΩ). You should hear the signal from the speaker. Remove the wire from SIG. GEN. (∿) and connect it to SIG. GEN. (⎍), which is the square-wave output. Again touch it to SPEAKER (400Ω) and then to SPEAKER (4 kΩ). If you turn the ADJUST FREQ. knob, you will hear the change in the frequency (pitch) of the signal generator as heard from the speaker.

If the results of these tests are satisfactory, your design console is ready for use. Turn the switch to OFF and unplug the line cord.

Notice that you can store your multimeter and many experimental parts in the smaller Basic Design Console, which will now fit into the cavity of your completed Electro-Lab® Design Console.

PLEASE NOTE CAREFULLY. Your design console is rugged. However, like any other laboratory instrument, it could be damaged by rough handling. Be careful not to accidentally short circuit any power output terminals. Before turning the switch from its OFF position, turn the ADJUST VOLTAGE knob fully counterclockwise, and while metering the output voltage, slowly advance the knob to obtain the desired output voltage. This protects the power supply from an accidental short circuit that might be present in an experimental circuit. No warm up time is required, and therefore you can turn the power OFF when you are not using it.

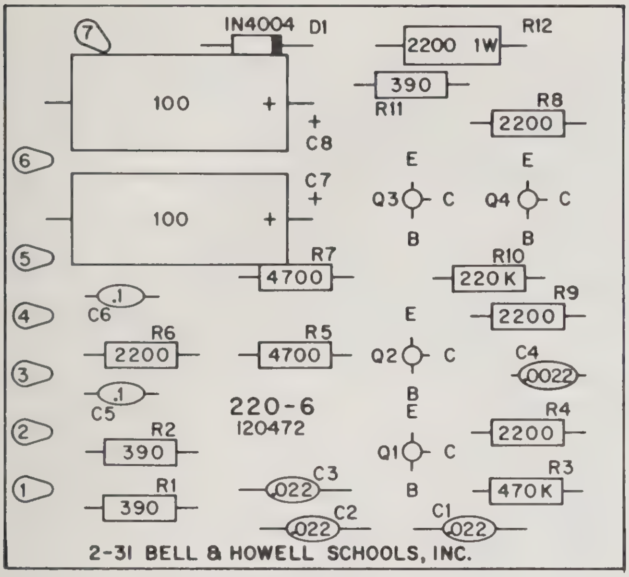


Figure 3-1

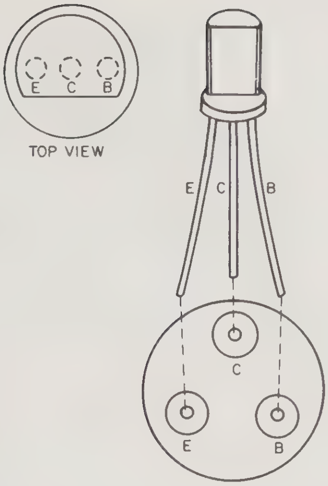


Figure 3-2

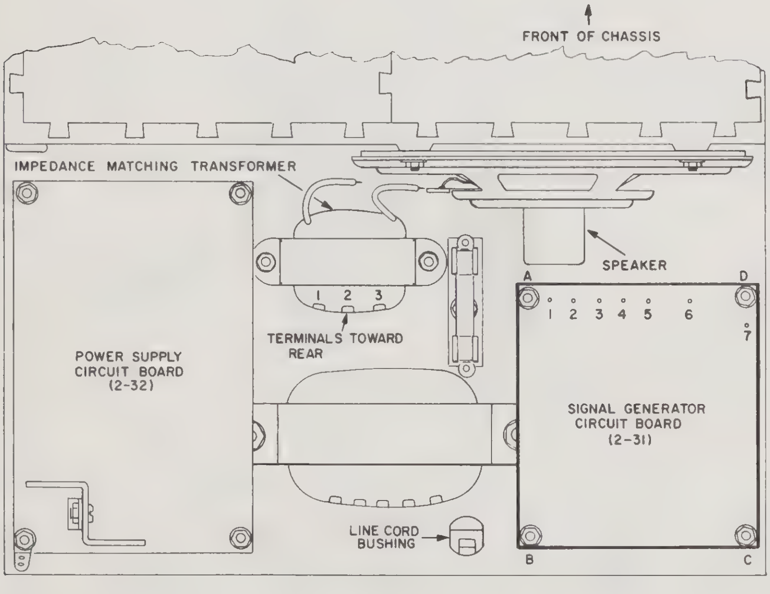

FRONT OF CHASSIS
IMPEDANCE MATCHING TRANSFORMER
1 2 3
TERMINALS TOWARD REAR
SPEAKER
A
D
1 2 3 4 5 6 7
POWER SUPPLY CIRCUIT BOARD (2-32)
SIGNAL GENERATOR CIRCUIT BOARD (2-31)
LINE CORD BUSHING
B
C

Figure 3-3

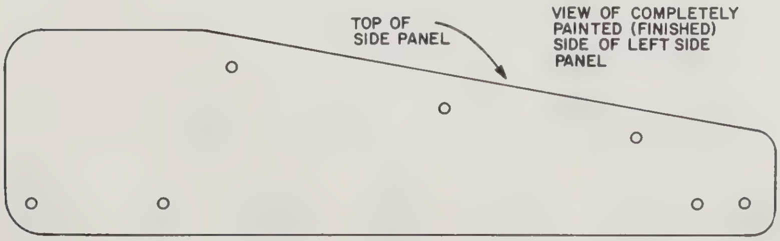

TOP OF SIDE PANEL
VIEW OF COMPLETELY PAINTED (FINISHED) SIDE OF LEFT SIDE PANEL

Figure 3-4

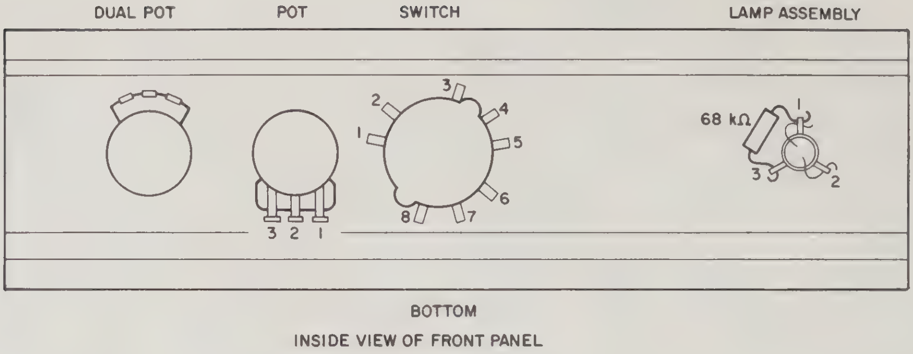


Figure 3-5

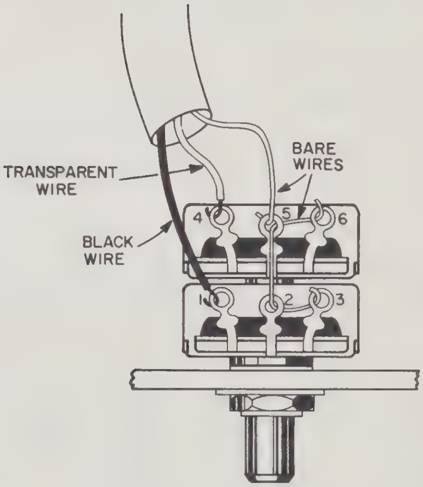
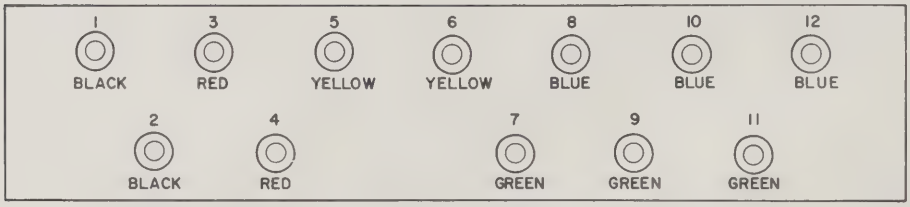
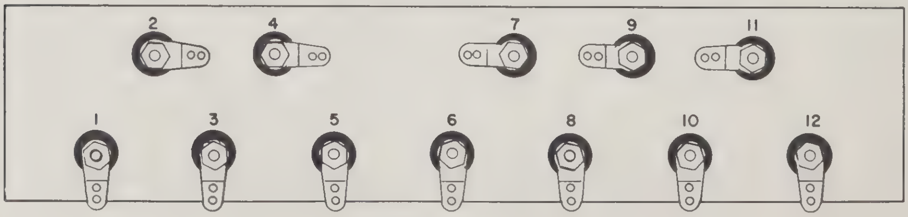


Figure 3-6



OUTSIDE VIEW



INSIDE VIEW

Figure 3-7

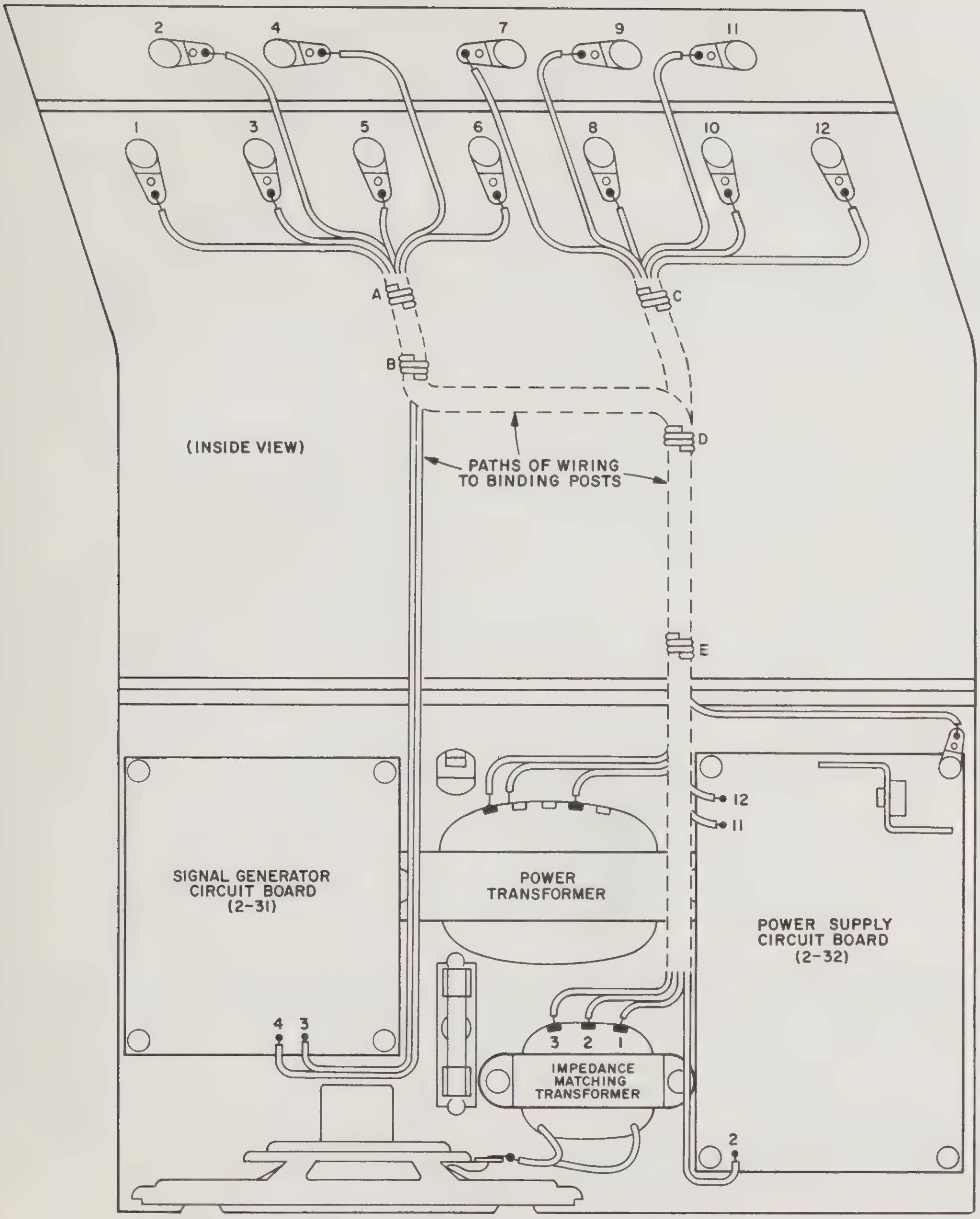

A
B
C
D
E
(INSIDE VIEW)
PATHS OF WIRING TO BINDING POSTS
SIGNAL GENERATOR CIRCUIT BOARD (2-31)
POWER TRANSFORMER
POWER SUPPLY CIRCUIT BOARD (2-32)
IMPEDANCE MATCHING TRANSFORMER

Figure 3-8

CIRCUIT ANALYSIS AND TROUBLESHOOTING

DISCUSSION

Information contained in this section consists of

(1) Specifications of the outputs or functions at the Electro-Lab® Design Console binding posts.

(2) Circuit description and analysis of

  (a) the power supply,

  (b) the signal generator, and

  (c) the speaker and impedance-matching transformer.

(3) General procedures for troubleshooting.

(4) Specific procedures for troubleshooting of your design console.

(5) Schematic diagrams of the circuits.

  Figure 4-1 The Power Supply

  Figure 4-2 The Signal Generator

  Figure 4-3 The Speaker and Impedance-Matching Transformer

OUTPUTS OR FUNCTIONS OF THE BINDING POSTS ON THE ELECTRO-LAB® DESIGN CONSOLE

Binding Post	*Output Voltage or Function*
EXT. GND.	Connected internally to the chassis of the design console. Connect this binding post to a good ground such as a water pipe or a cover plate screw at the ac outlet to eliminate any possible line voltage shock hazard and to reduce electrical noise problems.
REG. DC (—) REG. DC (+)	These binding posts supply adjustable, regulated dc voltage over two ranges selected by the **OFF-6V-30V** panel switch. On the **6V** range the output is adjustable from about 1V dc to 4V dc at 300 mA and 4.1V dc to 6V dc at 400 mA maximum current rating. This range should be used whenever the required output voltage is within these limits. On the **30V** range the output is adjustable from 6V to 15V dc at 100 mA, 15.1V dc to 25V dc at 150 mA and 25.1V dc to 30V dc at 200 mA maximum current rating. This range should be used only when the required output voltage cannot be obtained on the **6V** range.

Binding Post	*Output Voltage or Function*
	The **REG. DC (—)** binding post is the common negative terminal for **REG. DC (+)**, **+180V** and both **SIG. GEN.** outputs.
+180V REG. DC (—)	These binding posts supply unregulated dc voltage for relatively high-voltage, low-current circuits. The no-load terminal voltage is about 190V dc. At the maximum current rating of 100 milliamperes, the available voltage is about 140V dc.
12.6V AC 6.3V—0—6.3V	The two **6.3V** binding posts supply 12.6V ac. The center-tap of this transformer winding is connected to the 0 binding post. Between either **6.3V** binding post and the **0** binding post, 6.3V ac is available. Maximum current that should be drawn at either 6.3V ac or 12.6V ac is 1 ampere.
SIG. GEN.(∿) SIG. GEN.(⎍) REG. DC (—)	These binding posts supply sinewave and square-wave outputs at about 4 to 8V at low current, adjustable in frequency from about 300 to 2400 Hz.
SPEAKER COM. 400Ω 4 kΩ	These binding posts are connected to a built-in speaker through an impedance-matching transformer, providing a choice of the two input impedances indicated. These binding posts are not connected internally to any other design console circuits. A signal source, such as from an experimental amplifier output, connected to either the **400Ω** or the **4 kΩ** and **COM.** binding posts will be transformer coupled to the built-in speaker.

CIRCUIT DESCRIPTION AND ANALYSIS OF THE POWER SUPPLY

Figure 4-1 is the schematic diagram for the power supply. Most of the smaller power supply components are mounted on circuit board 2-32. External to the board are the line cord, fuse, power and voltage range switch, the **ADJUST VOLTAGE** control potentiometer, the neon lamp and its current limiting resistor, the power transformer and the binding posts.

The design console ac power input circuit consists of the line cord, a fuse, section **SW$_{1A}$** of the **OFF-6V-30V** switch, power transformer primary winding, Terminals 6 and 7, the **POWER ON** lamp and its current-limiting resistor.

One power transformer secondary supplies either of two ac voltages to the regulated power supply, selected by section SW$_{1B}$ of the switch. This is done to minimize the power dissipated in series regulator transistors Q$_4$. Another power transformer secondary winding, connected to Terminals 1 and 8, supplies a relatively high voltage at low current. The third secondary winding is connected to Terminals 2, 10 and 5, and from there to three binding posts. It supplies 12.6V ac, center-tapped, to these binding posts.

The high-voltage section of the power supply consists of half-wave diode rectifier D_5, filter capacitor C_5 and bleeder resistor R_7 that discharges C_5 when the power is removed. This power supply is independent of other internal design console circuits except that its negative lead is connected to the common "negative DC" circuit connected to the REG. DC (—) binding post.

The regulated adjustable power supply receives the ac voltage, selected by SW_{1B}, at circuit board Terminals 3 and 5. Diodes D_1, D_2, D_3 and D_4 are in a full-wave bridge rectifier circuit. Capacitor C_2 filters the rectified ac to provide dc power for the regulator portion of the power supply. Capacitor C_1 reduces the effects of any noise and spike disturbances that may exist in the 115V ac power line.

The voltage regulation insures an unvarying dc voltage for any value of load current within specified limits, and for line voltage variations within about 15V ac. This regulation is accomplished by series regulator transistor Q_4.

Note that Q_4 is connected between the dc unregulated source and any load connected to the REG. DC binding posts. Transistor Q_4 operates as a variable resistor, controlled by the voltage at its input (base) circuit. Since Q_4 may dissipate considerable power in the form of heat, it is mounted on a "heat sink" or cooler that prevents a destructive temperature rise. Transistor Q_4 dissipates power, as a resistor. Dissipation as expressed in watts is $E \times I$, where E is the voltage across the transistor and I is the current through it (the load current).

To obtain regulation, the output voltage is compared with a constant reference voltage. The difference between these voltages is amplified and used to control the base current of Q_4 and therefore its collector-to-emitter resistance.

Voltage divider resistors R_4 and R_5 feed about 55% of the output voltage to the base of Q_2. An adjustable percentage of a constant reference voltage from the emitter of Q_1 is obtained by the ADJUST VOLTAGE potentiometer, R_6. This voltage is applied to the emitter of transistor Q_2. Transistor Q_2 amplifies the difference between its base and emitter voltages. This amplified voltage is applied to the base of driver transistor Q_3, arranged in an "emitter follower" circuit, that supplies base current to control the series regulator transistor Q_4.

Capacitor C_3 provides additional filtering to reduce the 120 Hz power supply ripple. C_4 reduces any internally generated noise and provides a low impedance path to fast load current changes.

With the switch in the **30V** position, current flows through R_1 and Zener diode D_7. Current through this diode establishes a constant voltage drop across it. This reference voltage (33V dc) is applied to the base (input) of transistor Q_1 in an "emitter follower" circuit that has a high and fairly constant input resistance. The emitter circuit of Q_1 provides a slightly reduced but constant voltage to R_2 and the ADJUST VOLTAGE potentiometer R_6, and also amplifier transistor Q_2 via its load resistor R_3. Transistor Q_1 also functions as a current amplifier to isolate Zener diode D_7 from load current changes and thereby improves the Zener output and the overall regulation. With the switch in this **30V** position, about 33V ac is applied through transformer Terminals 4 and 9 and switch SW_{1B} to the input of the regulated power supply. The supply should be used for voltages between about 6V to 32V dc.

Turning the switch to the **6V** position causes about 9V ac to be applied through transformer Terminals 3 and 4 to the input of the regulated power supply via SW_{1B}. In this position, the third section of switch, SW_{1C} connects Zener diode D_8 across Zener diode D_7. Zener diode D_8 conducts through R_1. This generates a lower reference voltage of 9.1V. Since D_7 requires about 33V to conduct, it is cut off. The power supply delivers from about 1V to about 7.5V dc. This lower voltage range prevents accidental damage to low-voltage devices such as some integrated circuits that operate at 5V dc by limiting the maximum voltage that can be applied to them to a safe value. This range also limits the power dissipation of transistor Q_4 to reasonable values.

CIRCUIT DESCRIPTION AND ANALYSIS OF THE SIGNAL GENERATOR

Figure 4-2 is the signal generator schematic diagram. All components are mounted on circuit board 2-31, except for the ADJUST FREQ. dual potentiometer R_{13} and the output binding posts. This signal generator power supply is independent of the adjustable regulated power supply, so that the generator operating voltage and output voltages remain constant during changes in power supply outputs. Power transformer Terminals 1 and 9 supply about 33V ac to the signal generator circuit board, where rectifier diode D_1 and the filter, consisting of C_8, R_{12} and C_7 provide about 20V dc for its operation. Look again at Figure 4-1. Note that transformer Terminal 4 is connected to transformer Terminal 1 through diode D_4 on power supply board 2-32.

Transistor Q_1 operates as a "phase-shift" oscillator, with its frequency adjusted by the dual potentiometer R_{13}. Q_2, an emitter follower, provides the sinewave output to external circuits, and drives the square-wave generator incorporating transistors Q_3 and Q_4. This square-wave generator is a simple emitter-coupled bistable circuit that abruptly switches from one output level to another as its input voltage rises and falls. The sinewave output is available between binding posts 5 and 2. The square-wave output is available between binding posts 6 and 2.

CIRCUIT DESCRIPTION AND ANALYSIS OF THE SPEAKER AND IMPEDANCE-MATCHING TRANSFORMER

Figure 4-3 shows the speaker/transformer schematic diagram. The speaker has a typically low impedance of about 3.2 ohms, and is commonly called a "4-ohm" speaker. The transformer primary is tapped so that the speaker may be efficiently driven by transistor or vacuum-tube amplifiers. The three binding posts connected to the impedance-matching transformer primary are isolated from all other circuits in the design console.

GENERAL PROCEDURE FOR TROUBLESHOOTING

1. All components and much of the wiring inside the design console are available for inspection when the front and rear panels are swung open. To open the rear panel, remove the top rear hex-head screws with your ¼″ nut-driver, and loosen the bottom rear screws on both side panels. To open the front panel, remove the top front screws and loosen the two bottom front screws on both side panels. Open the panels carefully to avoid scratching the side panels.

2. Review the description of the operation of the design console circuits given above while you refer to the related schematic diagram. This information will aid you in locating the source of trouble and making repairs.

3. Define the trouble. For example, the symptom might be one of the following: (1) no outputs from the design console, (2) an output from only two binding posts of the **6.3V-0-6.3V** ac supply, (3) normal output but **POWER ON** lamp does not light, and (4) there is no output voltage from the **+180V** supply, even though all other sections of the design console seem to be working properly.

4. Once the trouble has been defined, use the senses of sight, touch and smell in the search for the source of the trouble. Look for signs of trouble. Look for components that may have been overheated by an abnormally high current. A resistor may be discolored or swollen in size. The power transformer may show signs of overheating. Since a defective component may be caused by a problem such as a short circuit, refer to the schematic diagram and locate the circuit that could be faulty.

Suppose that the **POWER ON** lamp does not light. Is the line cord properly plugged in? Is there ac voltage at the outlet? Suppose the **POWER ON** lamp does not light but output voltages seem normal. You might find that the wire leads of the lamp are touching each other. Suppose that there is no 12.6V ac available, but 6.3V ac is found at 2 binding posts. You might find a poor soldered joint or a broken wire in the other binding post circuit.

5. Look for a poor connection by inspecting all visible soldered connections. Test the wiring by carefully pulling on it by hand or with your long-nose pliers. A nicked wire may have broken, and the break may be concealed by its insulation or by another wire. Resistance measurements may locate poor connections.

6. If possible, locate trouble by resistance measurements with the line cord disconnected. If the power is on, be careful of line voltage in the primary circuit and voltages in the +180V power supply section.

7. Before making voltage measurements, be sure that your multimeter has been switched to the proper voltage range. Applying voltage to the meter when it is either incorrectly switched to too low a voltage range or a current or resistance range can damage the meter.

SPECIFIC PROCEDURES FOR TROUBLESHOOTING

NORMAL VALUES FOR RESISTANCE OR VOLTAGE ARE SHOWN IN PARENTHESES. If you obtain values differing by about 20% or more from those given, trouble exists in wiring, in a connection or in a component. BEFORE MEASURING VOLTAGE, switch your multimeter to the correct voltage range. BEFORE MEASURING RESISTANCE, "zero" the meter by touching the test leads together. SYMPTOMS in the following table are numbered for reference purposes. Look for an observed SYMPTOM and the PROBABLE CAUSES. Before making the measurements given in PROCEDURE, look carefully for a wiring error, a broken wire, a poor soldered connection, a loose solder lug at a binding post or a visibly overheated component. When you have located the trouble, make the appropriate repairs and then test the overall operation by measuring output voltages at the binding posts.

SYMPTOM	PROBABLE CAUSES	PROCEDURE
1. No output voltages POWER ON lamp does not light	1.1 Design console not plugged into ac outlet 1.2 No ac voltage at outlet 1.3 Blown fuse 1.4 Wiring error 1.5 Diode D_1, D_2, D_3 or D_4 reversed	1.01 Plug in another line-operated device such as a lamp, or measure the ac voltage at the outlet (110 to 125V ac). 1.02 Disconnect the line cord. Refer to Figure 4-1. Remove the fuse and measure its resistance (0Ω). If the fuse has blown, BEFORE replacing it, look for a wiring error or shorted terminals at the power transformer. Turn the switch to OFF. Measure the resistance between switch Terminal 5 and the POSITIVE lead of the 1000 uF capacitor C_2. Note this reading. Reverse the test leads and repeat the same measurement. If you read below 250Ω both times, diode D_1 is reversed or shorted. In the same manner, measure between switch Terminal 5 and the NEGATIVE lead of C_2 to test diode D_3. Measure between power transformer Terminal 4 and the POSITIVE lead of C_2 to test diode D_2. Measure between power transformer Terminal 4 and the NEGATIVE lead of C_2 to test diode D_4. If you should read above 1000Ω both times while testing any one diode, that diode is open-circuited or poorly connected.

SYMPTOM	PROBABLE CAUSES	PROCEDURE
2. POWER ON lamp does not light All other operation normal	2.1 Wiring error in lamp circuit 2.2 Defective NE-2 neon lamp	2.01 Disconnect the line cord. See Figures 3-5 and 4-1. Measure the resistance at lamp assembly Terminals 2 and 3 (17Ω, because these terminals connect to the power transformer primary). Check the resistance of R_8 by measuring between the lamp assembly Terminals 1 and 3 (68 kΩ). 2.02 Connect the line cord to an ac outlet and turn on the design console. Measure the ac voltage at Terminals 2 and 3 of the lamp assembly (110 to 125V ac). If the checks of Step 2.01 indicated no problem, replace the NE-2 neon lamp.
3. No ac voltage between one 6.3V and 0 binding post All other operation normal	3.1 Wiring error 3.2 Poor connection 3.3 Loose solder lug at the binding post 3.4 Broken wire	3.01 Disconnect the line cord. Refer to Figure 4-1. Measure the resistance between the power transformer terminals and the corresponding binding posts to which they are connected, numbered as shown (0Ω).
4. No dc voltage between +180V and REG. DC (—) binding posts All other operation normal	4.1 Wiring error 4.2 Poor connection 4.3 Loose solder lug at binding post on circuit board, reversed or defective diode D_5 4.4 Power transformer winding to Terminals 1 and 8 open	4.01 Disconnect the line cord. See Figure 4-1. Inspect D_5 for correct polarity. Measure the resistance between the **+180V** and **REG DC (—)** binding posts (150Ω or 39 kΩ depending on the test lead polarity). If it measures 150Ω or less for either polarity, the diode is defective. 4.02 Disconnect the line cord. Measure the resistance at power transformer Terminals 1 and 8 (61Ω).
5. No dc voltage at REG. DC binding posts All other operation normal	5.1 Wiring error 5.2 Poor connection 5.3 Broken wire 5.4 Loose solder lug 5.5 Poor connection at switch Terminal 3, 4 or 5 5.6 Poor connection at the **ADJUST VOLTAGE** potentiometer 5.7 Poor connection at power transformer Terminal 3, 4 or 9	5.01 Disconnect the line cord. Referring to Figures 3-5 and 4-1, check all wiring and connections shown in the PROBABLE CAUSES column before removing the circuit board for examination. 5.02 Resolder all doubtful connections not on the circuit board. 5.03 Set the **OFF-6V-30V** switch at **6V.** Measure the resistance between switch Terminal 5 and power transformer Terminals 3 (0Ω), 4 (0Ω) and 9 (0Ω).—This checks the switch connections between Terminals 4 and 5.

SYMPTOM	PROBABLE CAUSES	PROCEDURE
	5.8 On the power supply circuit board, poor connection at Terminal 3 or 5, at R_1, R_2, R_3 or R_4	5.04 Set the switch to the **30V** position. Measure the resistance between switch Terminal 5 and power transformer Terminals 3 (0Ω), 4 (0Ω) and 9 (0Ω).—This checks the switch connections between Terminals 3 and 5. 5.05 Measure the resistance between the **REG. DC** binding posts (500Ω). This measures the resistance of R_4 plus R_5 and determines if they are properly connected on the circuit board. 5.06 Connect the line cord. Set the switch to **6V** and the **ADJUST VOLTAGE** knob fully clockwise. Look for any resistor that may be overheating. Make the following voltage measurements: Measure the dc voltage across the 1000 μF capacitor, C_2 (17V dc).—This checks the main low-voltage power supply circuits. Measure the dc voltage across **ADJUST VOLTAGE** potentiometer Terminals 1 and 3 (4.7V dc).—This checks R_1, Zener diode D_8, transistor Q_1, R_2 and the potentiometer. Measure the dc voltage across the 10 μF capacitor, C_3 (9.5V dc). Turn the **ADJUST VOLTAGE** knob fully counterclockwise and repeat the measurement (2.2V dc).—This checks the **ADJUST VOLTAGE** potentiometer, transistor Q_2, capacitor C_3 and R_3. 5.07 Set the switch to **30V** and the **ADJUST VOLTAGE** knob fully clockwise. Make the following measurements: Measure the dc voltage across the 1000 μF capacitor, C_2 (40V dc).—This checks the main low-voltage power supply circuits. Measure the dc voltage across Terminals 1 and 3 of the **ADJUST VOLTAGE** potentiometer (23V dc).—This checks Zener diode D_7, R_1, R_2, R_6 and Q_1. Measure the dc voltage across the 10 μF capacitor, C_3 (35V dc). Turn the **ADJUST VOLTAGE** knob fully counterclockwise and repeat the measurement (2.2V dc).

SYMPTOM	PROBABLE CAUSES	PROCEDURE
		5.08 If SYMPTOM 5 still exists, you will have to remove the power supply circuit board for closer examination. 5.09 Disconnect the line cord. 5.10 Remove the mounting hardware at each corner of the circuit board and put it aside in a small container until needed. Do not disconnect external lead wires. 5.11 Carefully examine the copper foil side of the board. Check all soldered connections and resolder any that appear doubtful. Look for a break, perhaps a hairline crack, in the copper foil conductors. Solder over any break you discover. You may lay a short piece of bare wire over the break before soldering. 5.12 Check the dc output voltage at the **REG. DC** binding posts before remounting the circuit board. Insulate it from the chassis and the two transformers with paper while making this check. 5.13 When the trouble is corrected, reinstall the circuit board and realign transistor Q_4 if required.
6. High nonadjustable voltage at REG. DC binding posts on 6V or 30V range	6.1 Transistor Q_1, Q_3 or Q_4 is defective	6.01 Disconnect the line cord. 6.02 Remove the power supply circuit board as in PROCEDURE, 5.08. 6.03 Refer to Figure 4-1. Remove transistors Q_2, Q_3 and Q_4. Test them, and replace any that are defective.
7. Poor regulation and abnormally high voltage at the REG. DC binding posts but controlled by the ADJUST VOLTAGE knob, on 6V or 30V range	7.1 Poor connection of Zener diode D_7 or D_8 on the circuit board. Wiring error to switch Terminal 7 or 8. Poor switch contact on the **6V** position	7.01 If the SYMPTOM appears on the **6V** range, check the wiring and measure the resistance between switch Terminals 7 and 8 while switching from **6V** to **30V** to **6V** range. On the **6V** range, (0Ω).—This checks the switch contacts. If the SYMPTOM appears on the **30V** range, diode D_7 or its connection is defective. 7.02 Remove the circuit board, replace D_8 or D_7, test the power supply operation and replace the board. See PROCEDURE, 5.09 through 5.13.

SYMPTOM	PROBABLE CAUSES	PROCEDURE
8. REG. DC output voltage is erratic as ADJUST VOLTAGE knob is rotated	8.1 Poor rotor contact in ADJUST VOLTAGE potentiometer	8.01 Disconnect the line cord and refer to Figure 4-1. 8.02 Measure the resistance between the ADJUST VOLTAGE potentiometer Terminals 1 and 2 while turning the knob. If you find jumps or momentary $\infty\Omega$ indications, replace the potentiometer.
9. No output between either SIG. GEN. binding post and REG. DC (—) binding post	9.1 Wiring error from power transformer Terminals 1 and 9 to the signal generator circuit board. No common negative to signal generator circuit board. Wiring error to the binding posts 9.2 Diode D_1 open or reversed 9.3 Poor connection at R_{12} 9.4 Wiring error from **ADJ. FREQ.** dual potentiometer to the signal generator circuit board 9.5 Poor connection of R_1, R_2, R_3, R_4, R_5, R_6 or C_1, C_2, C_3 9.6 Q_1 defective	9.01 Connect the line cord and set the switch at **6V** and **ADJUST VOLTAGE** fully counterclockwise. Refer to Figures 3-1, 3-6 and 4-2. 9.02 Measure the dc voltage across the 100 μF capacitor, C_7 (20V dc).—This checks the operation of the signal generator power supply. 9.03 Turn the **ADJ. FREQ.** knob fully counterclockwise. Measure the resistance from Terminals 1 and 3 (10 kΩ), and 4 and 6 (10 kΩ) of the potentiometer.—This checks to see if the shielded wiring is shorted. 9.04 While measuring the ac voltage between the **SIG. GEN.** sinewave and **REG. DC (–)** binding posts, press on the circuit board near the components with a pencil eraser.—An intermittent output (about 5V ac) indicates a poor connection on the circuit board. 9.05 Disconnect the line cord and remove the circuit board. See PROCEDURE, 5.09, 5.10 and 5.11. Make the required repairs. 9.06 Check the output before remounting the circuit board. Insulate it from the chassis and the two transformers with paper while making the check. 9.07 Install the repaired circuit board and again test its output.
10. No output from the SIG. GEN. square wave and REG. DC (—) binding posts, sinewave output o. k.	10.1 Wiring error to the binding post 10.2 Poor connection in the circuit board at R_7, R_8, R_9, R_{10} or R_{11} 10.3 Transistor Q_3 or Q_4 defective or improperly installed	10.01 Disconnect the line cord. 10.02 Inspect the wiring to the squarewave binding post. Refer to Figures 3-1, 3-8 and 4-2. 10.03 Connect the line cord and set the switch to **6V.** 10.04 While measuring the ac voltage between the **SIG. GEN.** square wave and

SYMPTOM	PROBABLE CAUSES	PROCEDURE
		REG. DC (–) binding posts, press on the circuit board near the components with a pencil eraser.—An intermittent output (about 5V ac) indicates a poor connection on the circuit board. 10.05 Disconnect the line cord and remove the circuit board. See PROCEDURE, 5.09, 5.10 and 5.11. Make the required repairs. 10.06 See 9.06. 10.07 Install the repaired circuit board and again test its output.
11. Loudspeaker does not operate, with signal voltage applied between SPEAKER COM. and either 400Ω or 4 kΩ binding posts	11.1 Wiring error 11.2 Poor connection 11.3 Loose solder lug at the binding post 11.4 Defective transformer 11.5 Defective speaker	11.01 Disconnect the line cord. Refer to Figure 4-3. 11.02 Measure the resistance between **SPEAKER COM.** and **400**Ω binding posts (16Ω). Measure the resistance between **SPEAKER COM.** and the **4 k**Ω binding posts (183Ω).—This checks the primary circuit of the impedance-matching transformer. 11.03 Measure the resistance of the speaker at its terminals (3Ω). 11.04 Disconnect the lead at the top speaker terminal. Measure the resistance of the transformer secondary winding (1Ω).

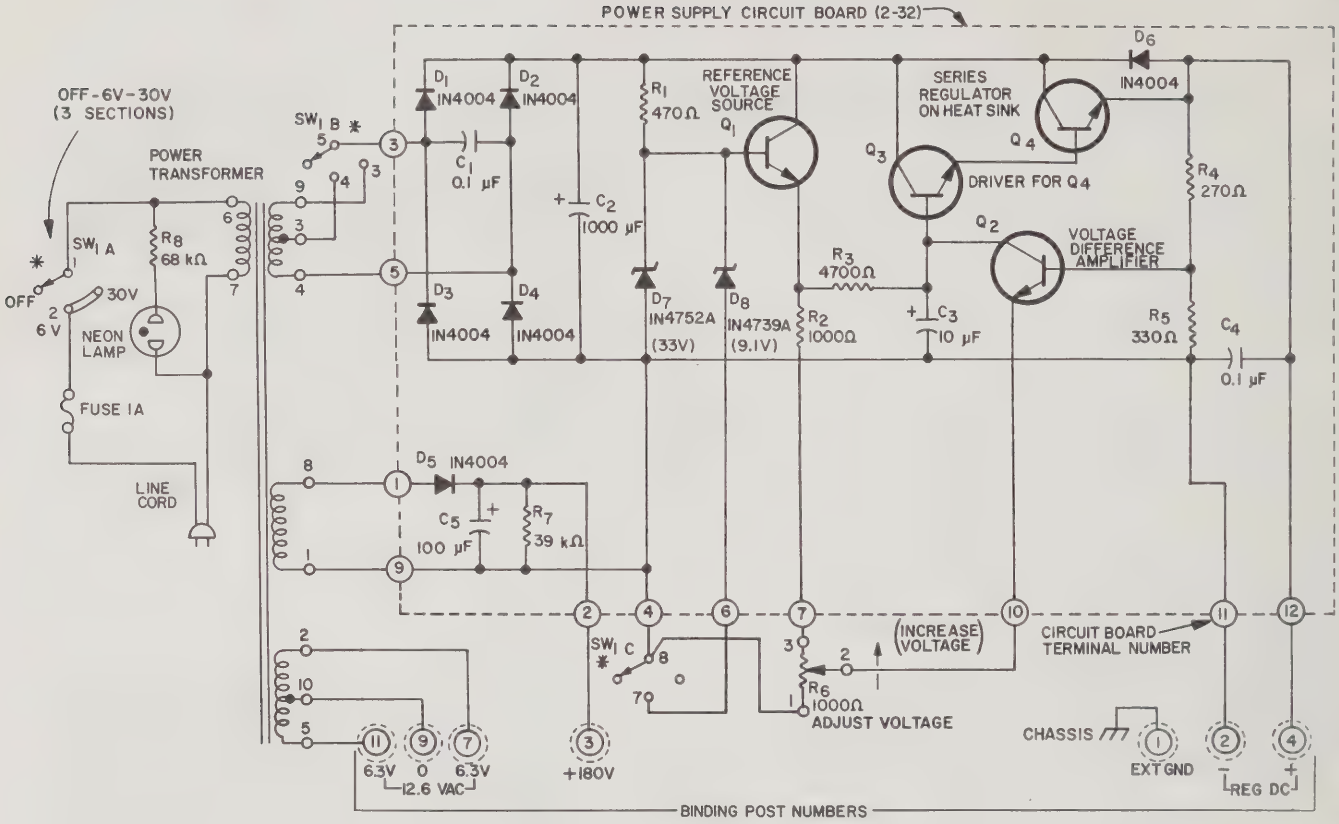

POWER SUPPLY CIRCUIT BOARD (2-32)
OFF-6V-30V
(3 SECTIONS)
POWER
TRANSFORMER
SW1 A
OFF
6 V
30V
R8
68 kΩ
NEON
LAMP
FUSE 1A
LINE
CORD
SW1 B
D1
IN4004
D2
IN4004
C1
0.1 μF
C2
1000 μF
D3
IN4004
D4
IN4004
R1
470Ω
REFERENCE
VOLTAGE
SOURCE
Q1
D7
IN4752A
(33V)
D8
IN4739A
(9.1V)
R2
1000Ω
R3
4700Ω
C3
10 μF
SERIES
REGULATOR
ON HEAT SINK
Q3
DRIVER FOR Q4
Q4
Q2
VOLTAGE
DIFFERENCE
AMPLIFIER
D6
IN4004
R4
270Ω
R5
330Ω
C4
0.1 μF
D5
IN4004
C5
100 μF
R7
39 kΩ
SW1 C
(INCREASE
VOLTAGE)
R6
1000Ω
ADJUST VOLTAGE
CIRCUIT BOARD
TERMINAL NUMBER
CHASSIS
EXT GND
REG DC
6.3V
0
6.3V
12.6 VAC
+180V
BINDING POST NUMBERS

Figure 4-1

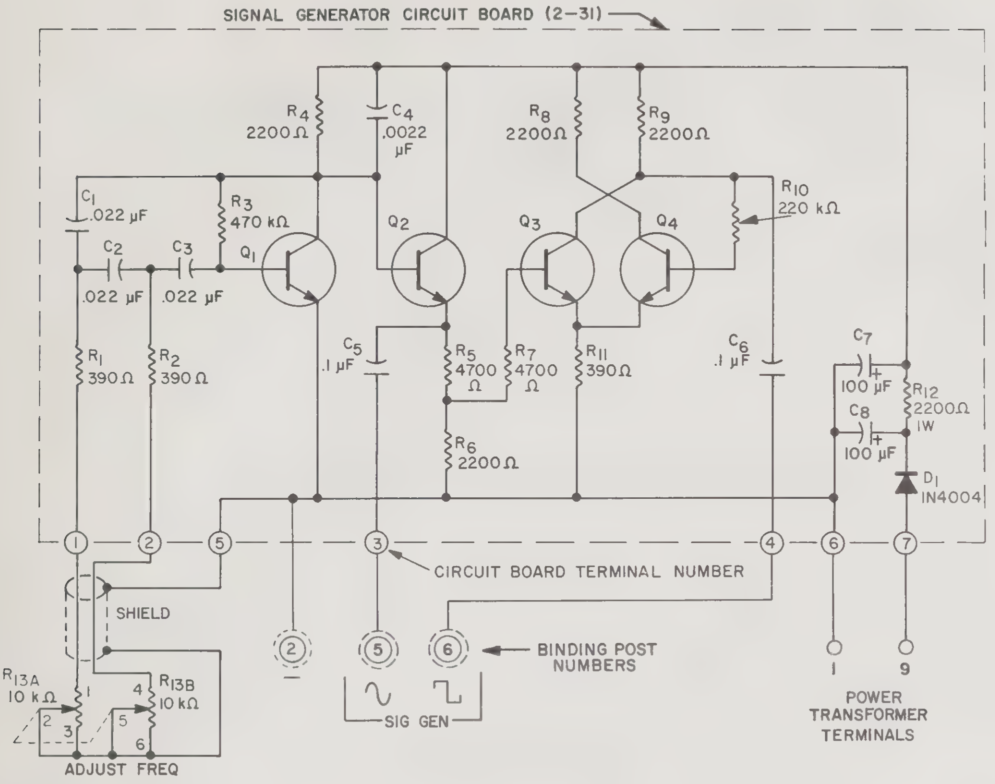


Figure 4-2

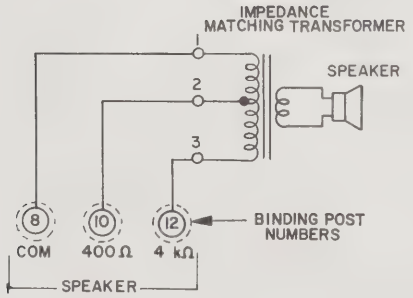
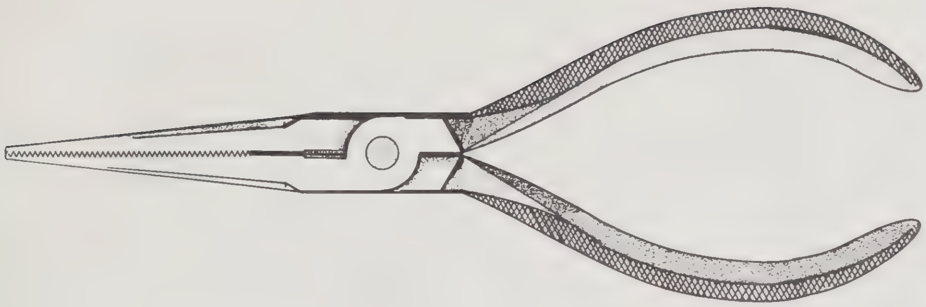
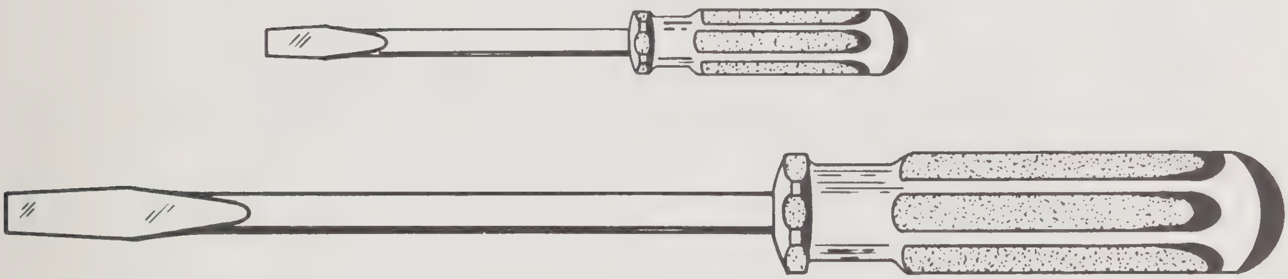


Figure 4-3

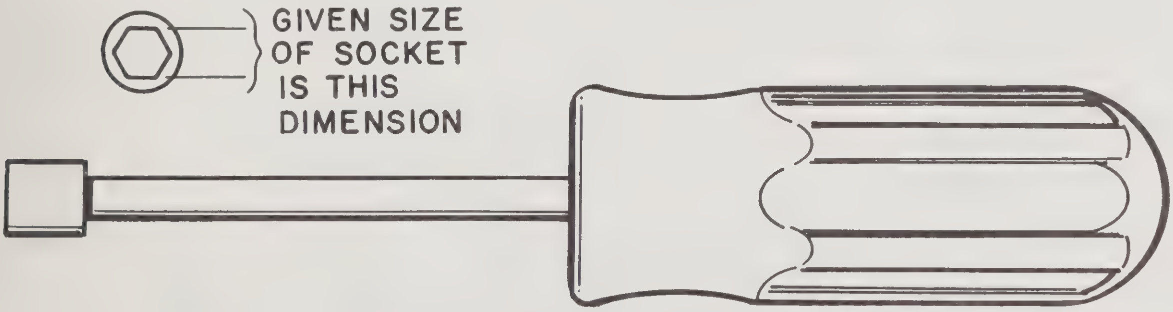


LONG-NOSE PLIERS



SCREWDRIVERS

A SCREWDRIVER should be selected so that its blade fits a screw slot as snugly as possible, and is wide enough so that the screw may be tightened without damaging the slot. When the squared-off screwdriver blade edges become rounded because of wear or misuse, they may slip out of a screw slot and cause damage to the screw or piece of equipment.



SOCKET-HEAD
NUT DRIVER

A SOCKET-HEAD NUTDRIVER is easy to use in a restricted space, and it may be used to hold a nut while a screw is tightened. If the proper size of socket is used, the socket will not slip off a nut and possibly mar a nearby surface. For that reason a ¼″ nutdriver could be used to tighten the hex-head screws which attach the side panels to the design console.

Figure 4

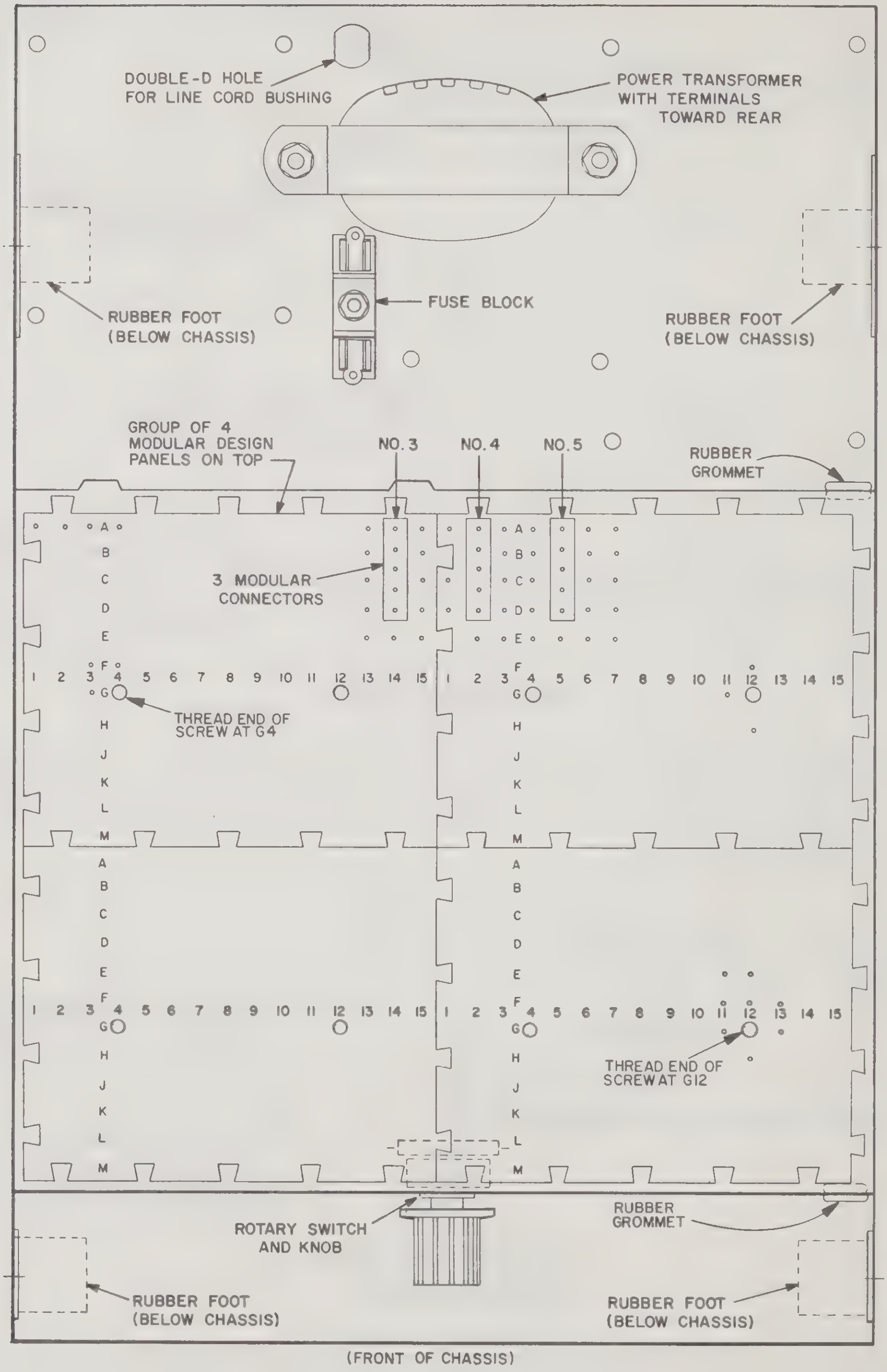

DOUBLE-D HOLE FOR LINE CORD BUSHING
POWER TRANSFORMER WITH TERMINALS TOWARD REAR
FUSE BLOCK
RUBBER FOOT (BELOW CHASSIS)
RUBBER FOOT (BELOW CHASSIS)
GROUP OF 4 MODULAR DESIGN PANELS ON TOP
NO. 3
NO. 4
NO. 5
RUBBER GROMMET
3 MODULAR CONNECTORS
THREAD END OF SCREW AT G4
THREAD END OF SCREW AT G12
ROTARY SWITCH AND KNOB
RUBBER GROMMET
RUBBER FOOT (BELOW CHASSIS)
RUBBER FOOT (BELOW CHASSIS)
(FRONT OF CHASSIS)

Figure 1-2

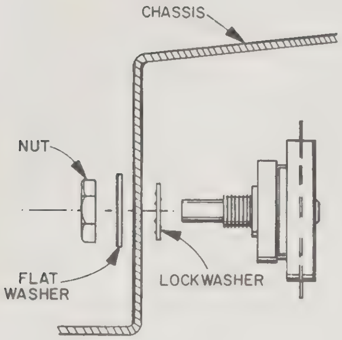


Figure 1-3

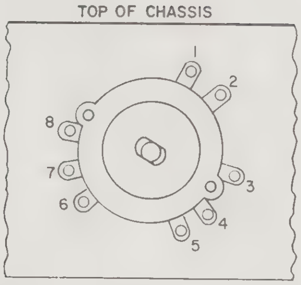


Figure 1-4

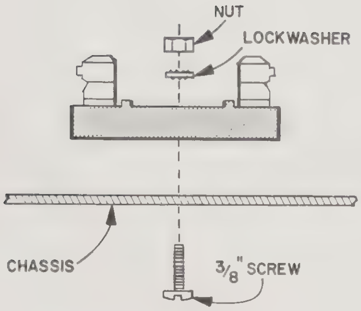


Figure 1-5

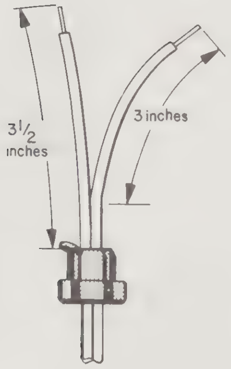


Figure 1-6

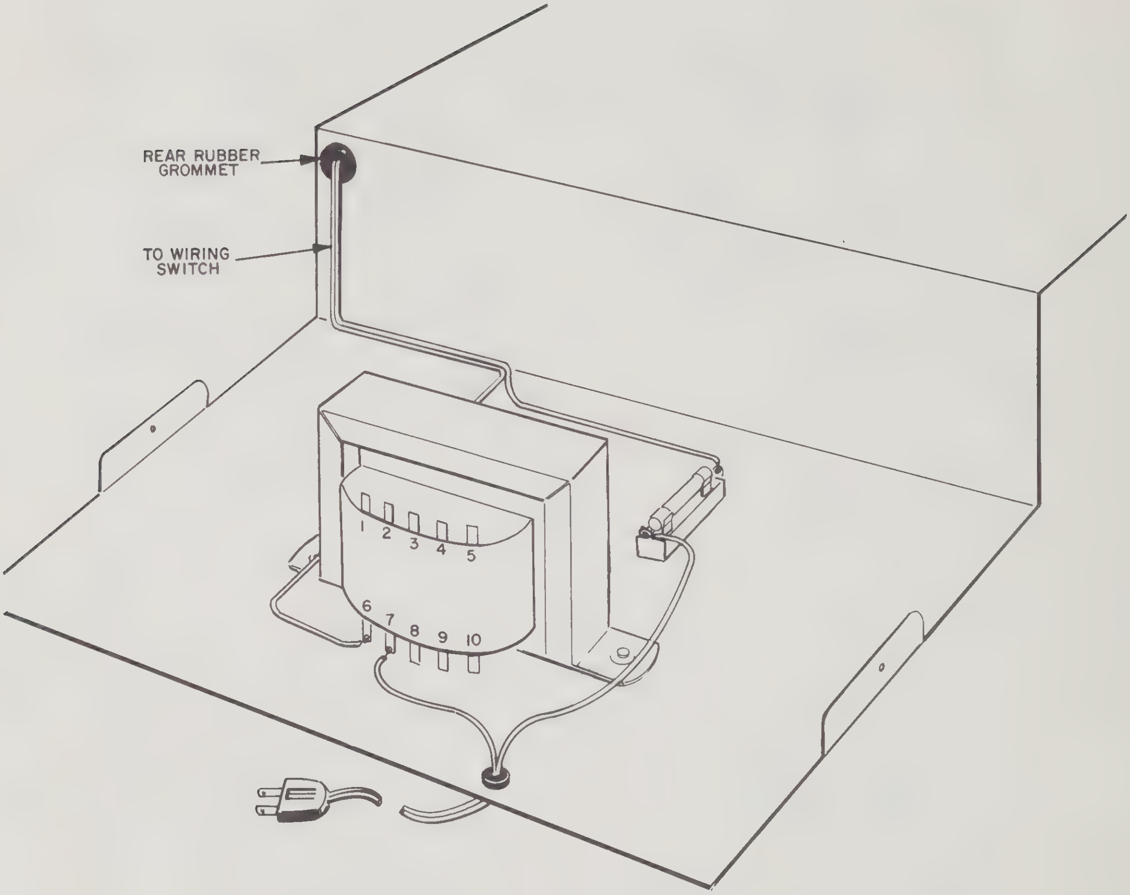


Figure 1-7

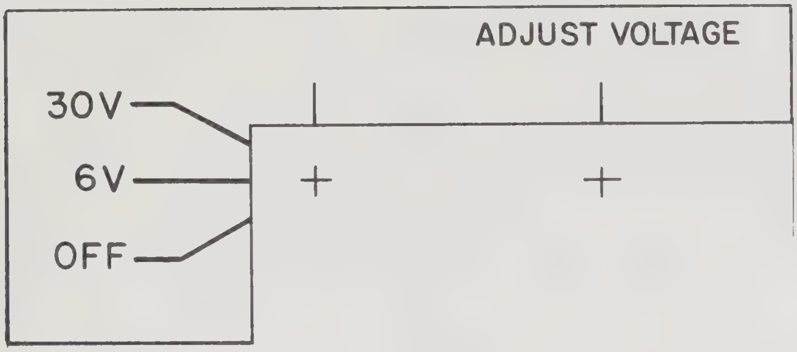


Figure 2-7

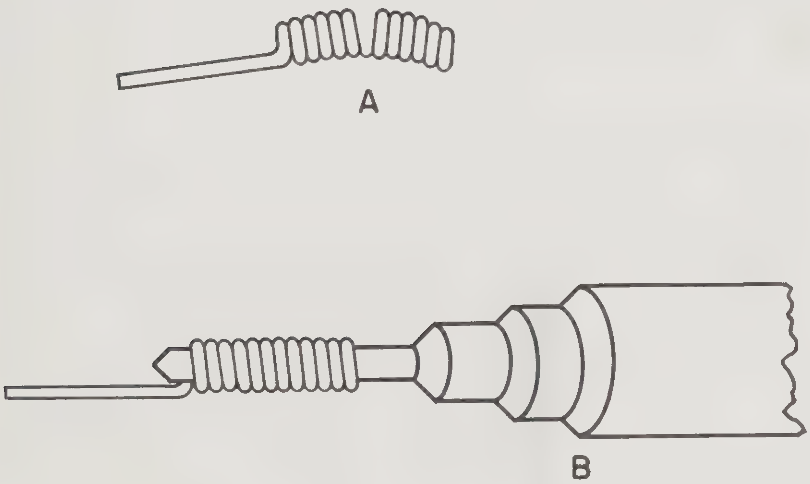


Figure 2-8

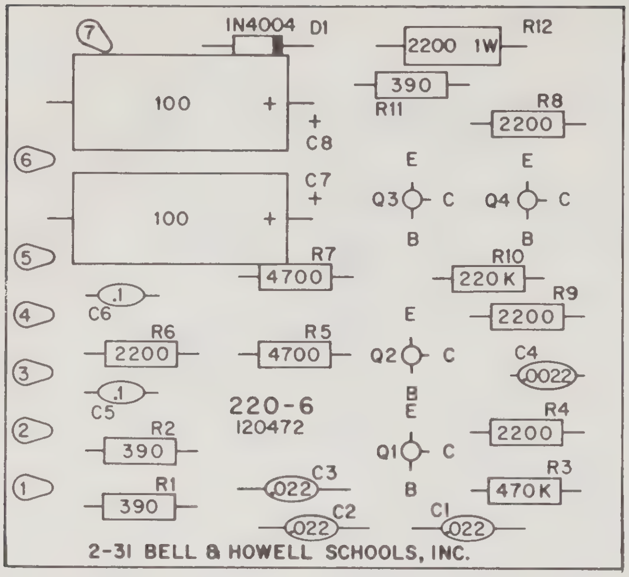


Figure 3-1

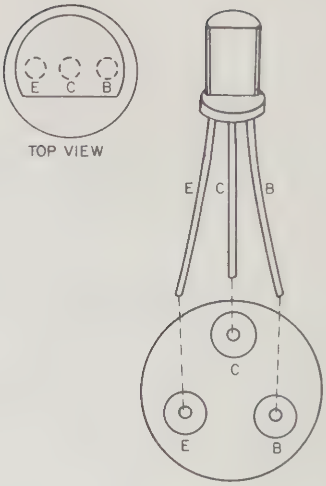


Figure 3-2

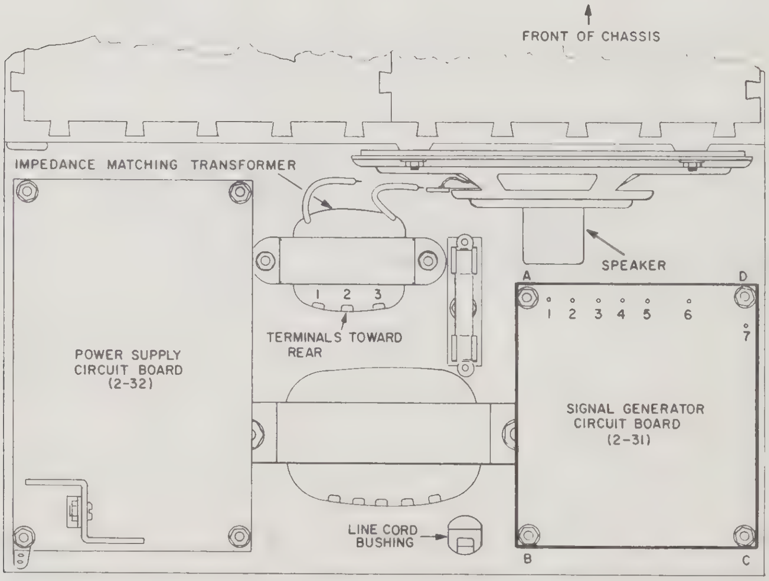

FRONT OF CHASSIS
IMPEDANCE MATCHING TRANSFORMER
SPEAKER
A
D
1
2
3
TERMINALS TOWARD REAR
1 2 3 4 5 6
7
POWER SUPPLY CIRCUIT BOARD (2-32)
SIGNAL GENERATOR CIRCUIT BOARD (2-31)
LINE CORD BUSHING
B
C

Figure 3-3

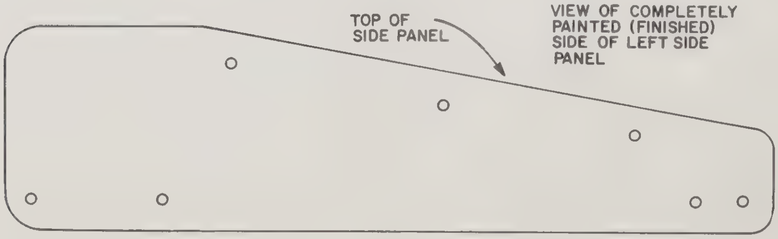

TOP OF SIDE PANEL
VIEW OF COMPLETELY PAINTED (FINISHED) SIDE OF LEFT SIDE PANEL

Figure 3-4

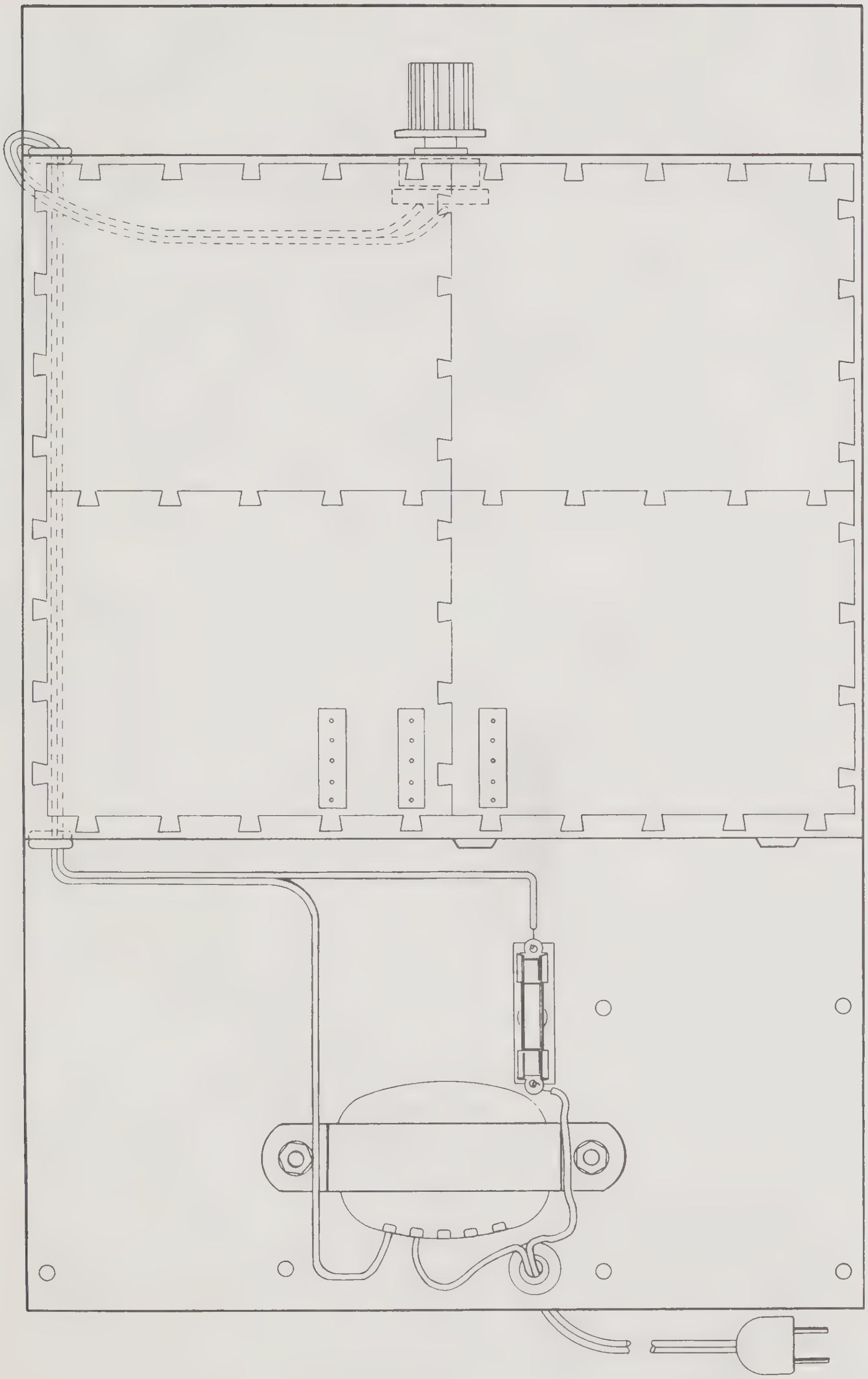


Figure 1-8

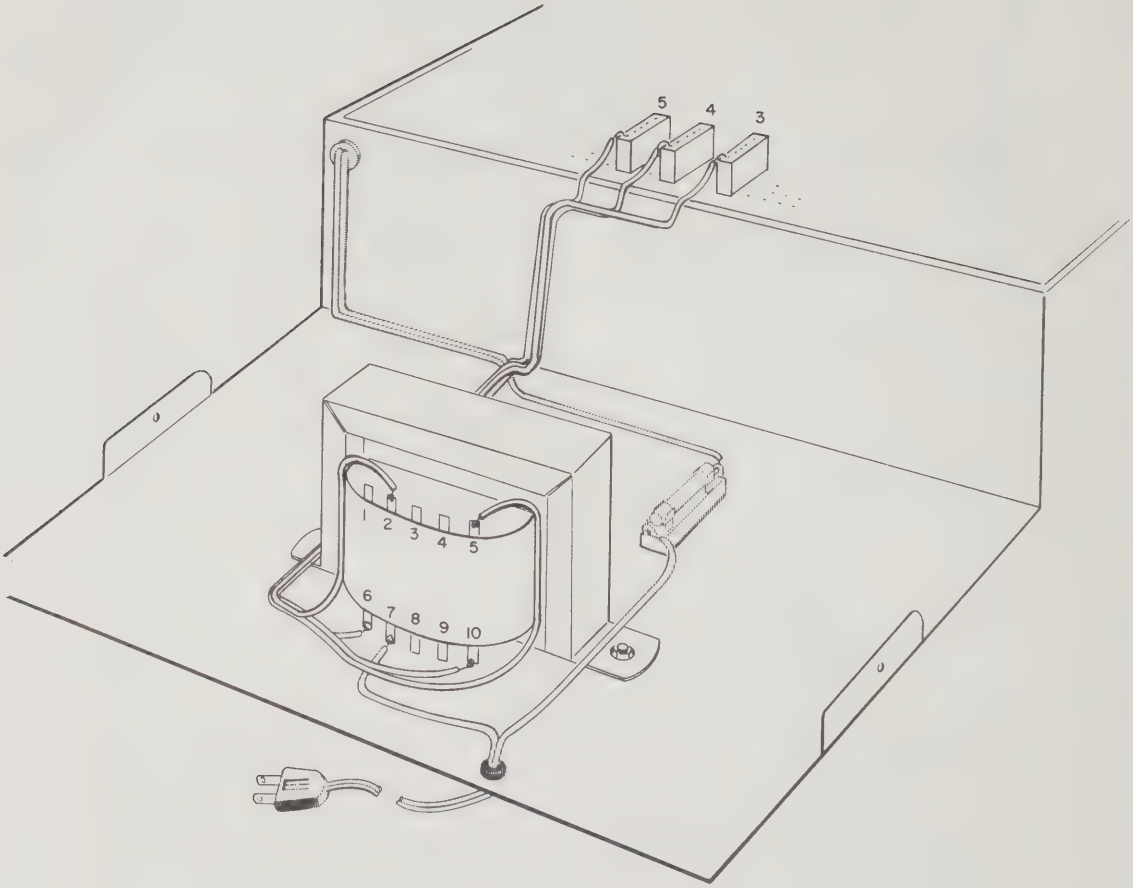


Figure 1-9

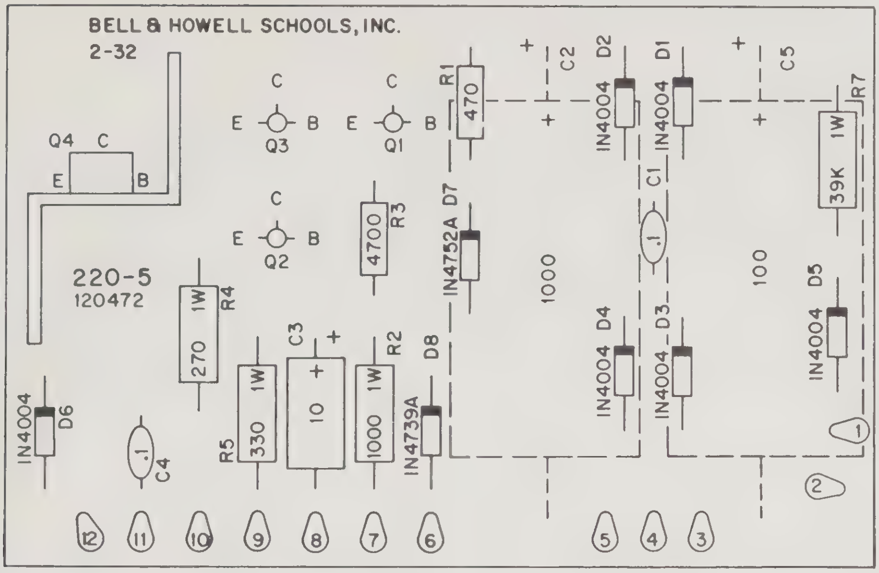


Figure 2-2

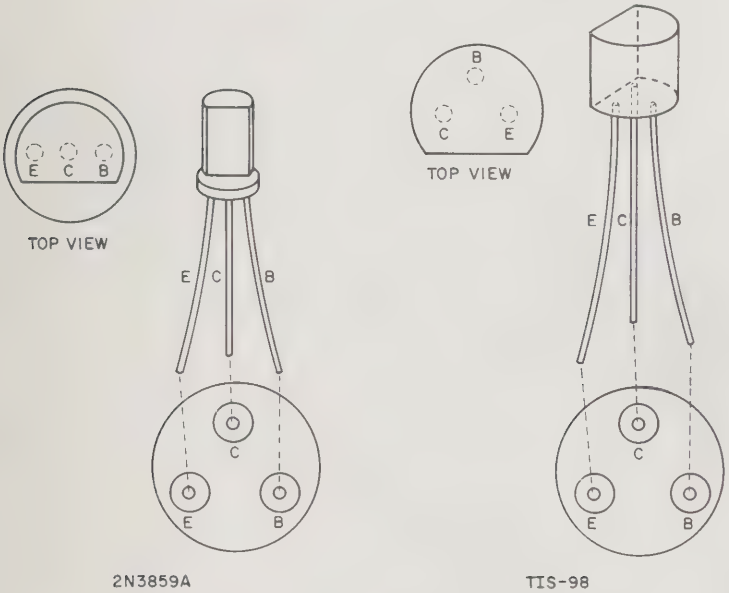


Figure 2-3

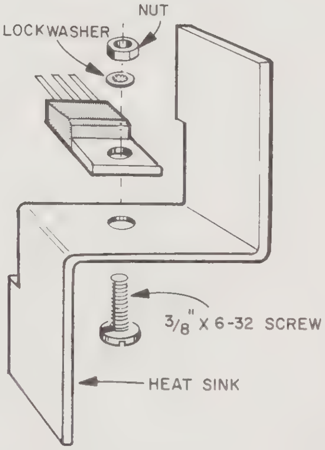


Figure 2-4

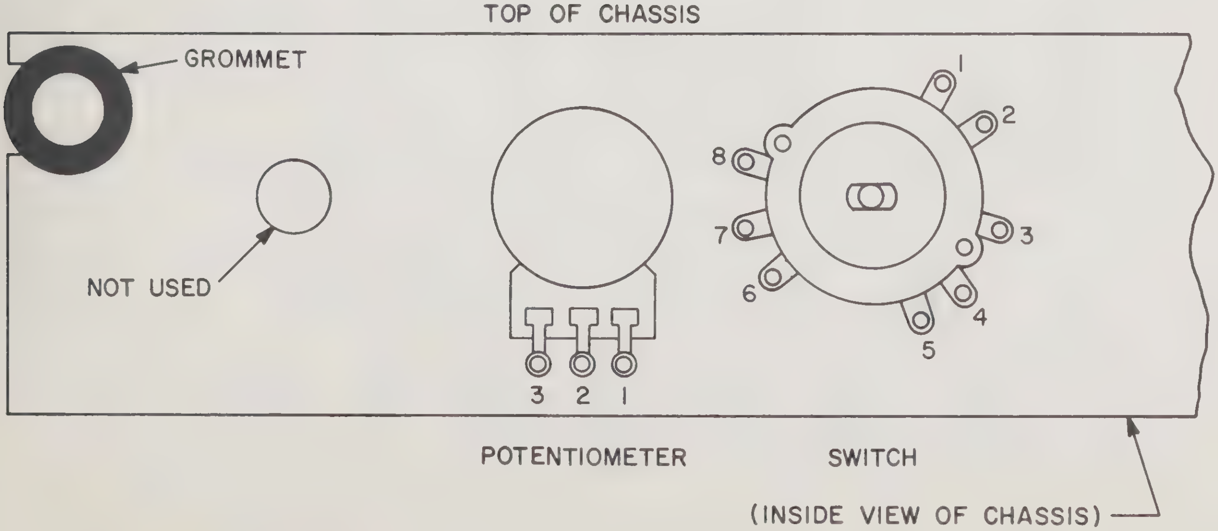


Figure 2-5

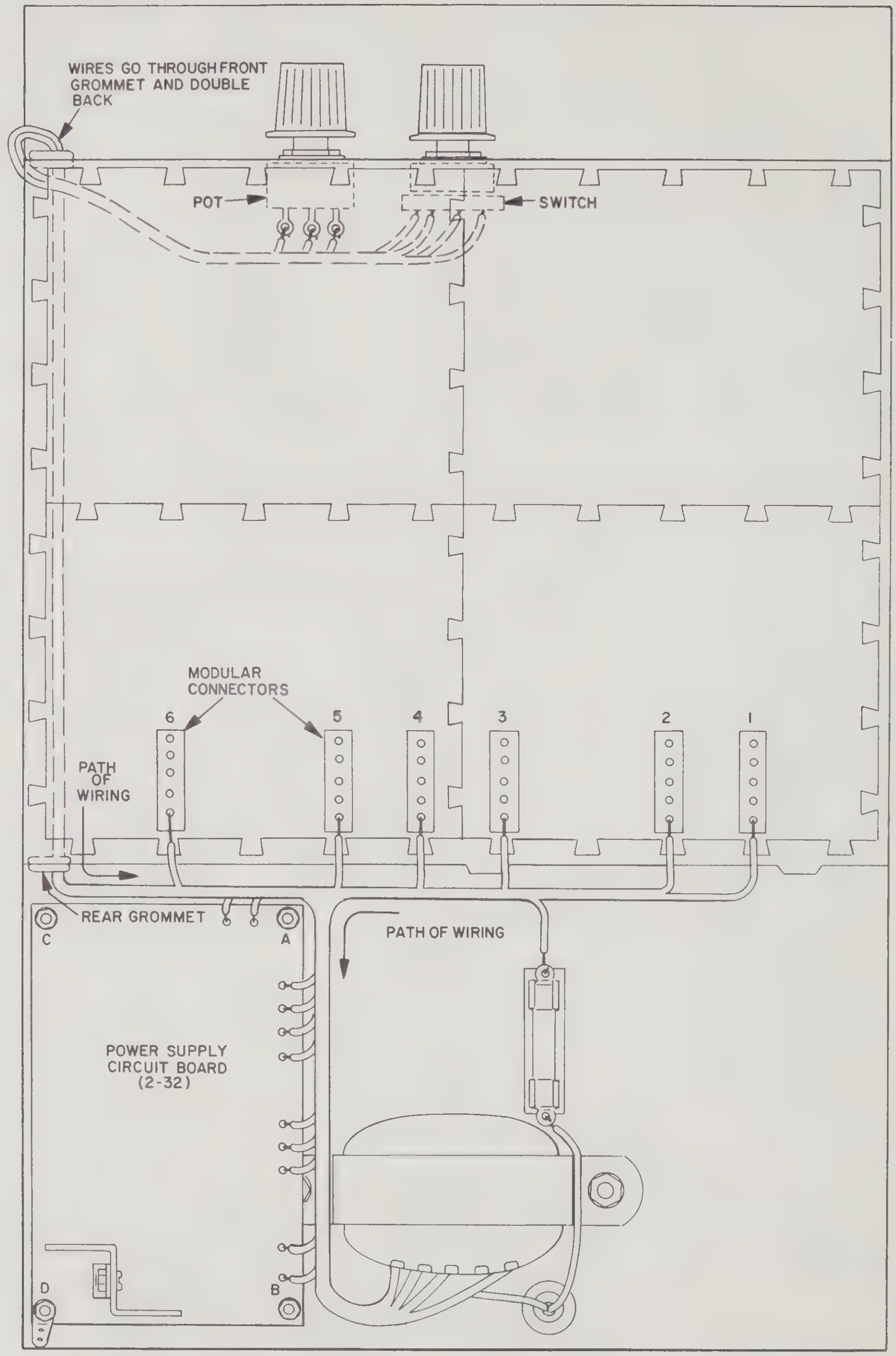

WIRES GO THROUGH FRONT GROMMET AND DOUBLE BACK
POT
SWITCH
MODULAR CONNECTORS
6
5
4
3
2
1
PATH OF WIRING
REAR GROMMET
C
A
PATH OF WIRING
POWER SUPPLY CIRCUIT BOARD (2-32)
D
B

Figure 2-6

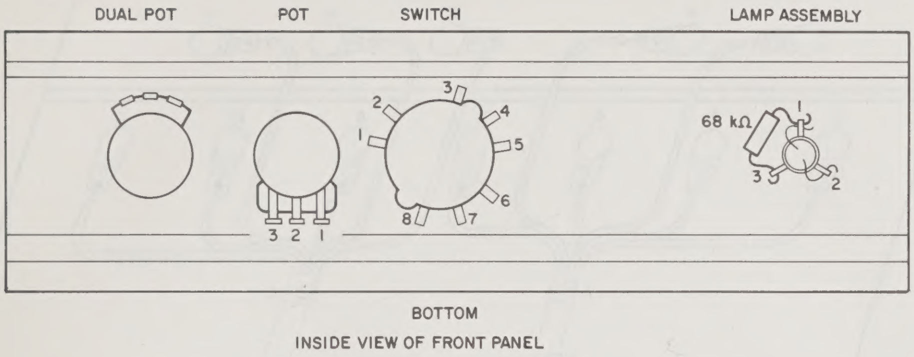


Figure 3-5

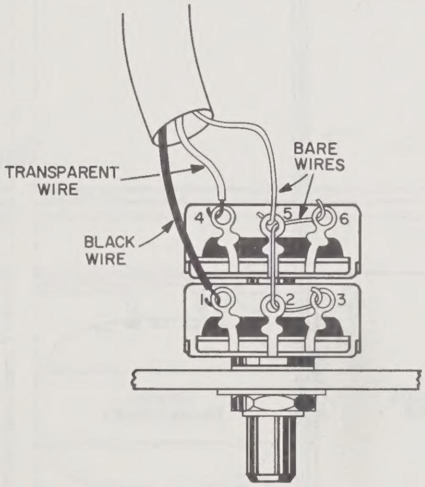


Figure 3-6

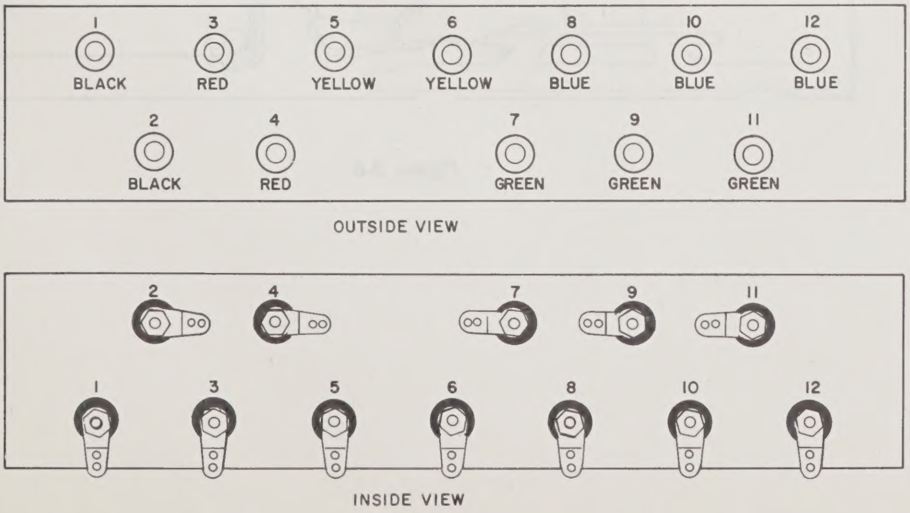


Figure 3-7

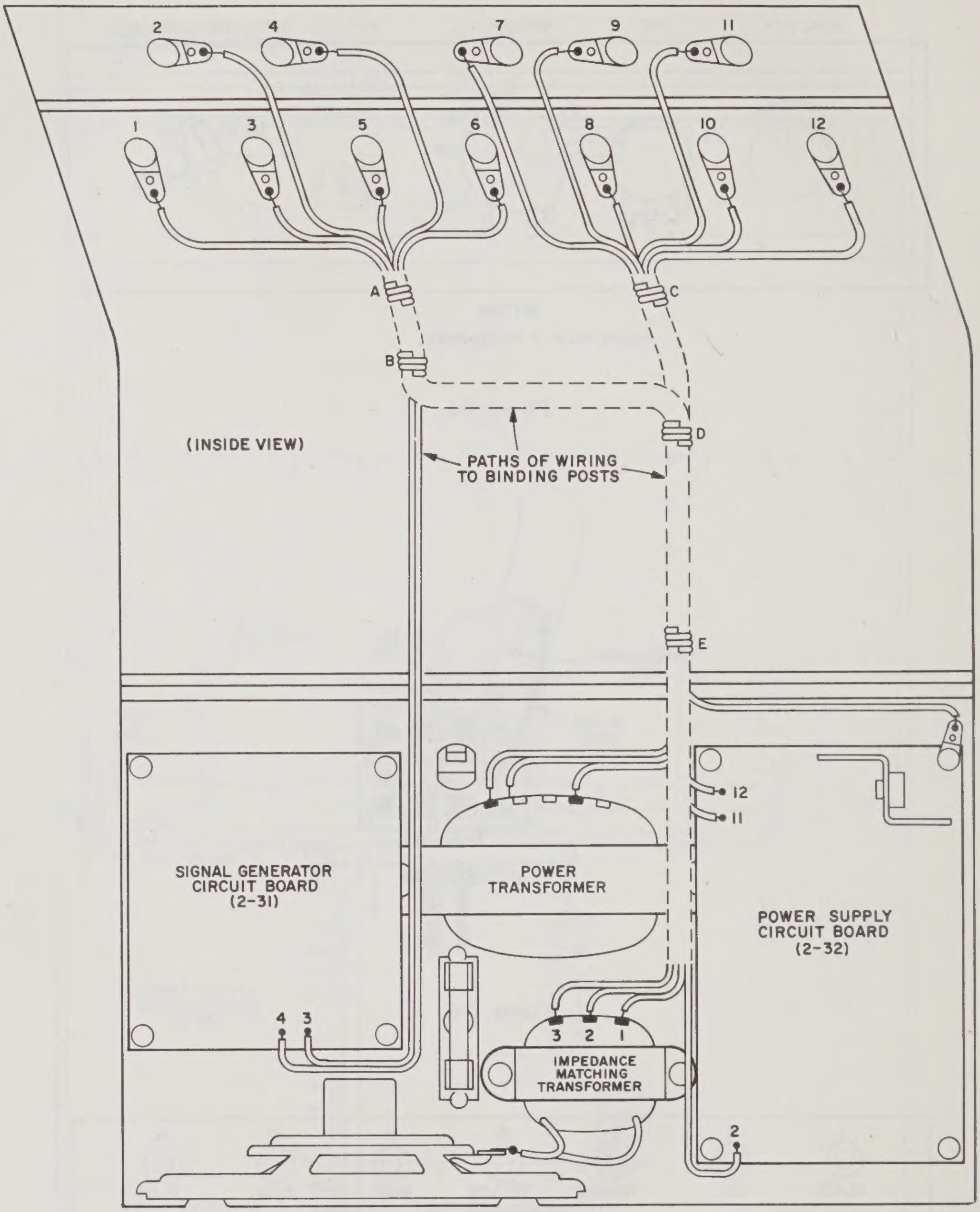

A
B
C
D
E
(INSIDE VIEW)
PATHS OF WIRING TO BINDING POSTS
SIGNAL GENERATOR CIRCUIT BOARD (2-31)
POWER TRANSFORMER
POWER SUPPLY CIRCUIT BOARD (2-32)
IMPEDANCE MATCHING TRANSFORMER

Figure 3-8